NRRC
SD397
W45
A44
1902

The D. H. Hill Library
North Carolina State University

NRRC
SD397
W45
A44
1902

FOREST RESOURCES
LIBRARY

N.C. STATE UNIVERSITY D.H. HILL LIBRARY
S00429573 U

THIS BOOK IS DUE ON THE DATE INDICATED BELOW AND IS SUBJECT TO AN OVERDUE FINE AS POSTED AT THE CIRCULATION DESK.

FOREST RESOURCES
LIBRARY

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 33.

GIFFORD PINCHOT, Forester.

THE WESTERN HEMLOCK.

BY

EDWARD T. ALLEN,

FIELD ASSISTANT, BUREAU OF FORESTRY.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

NRRC
SD397
W45
A44
1902

BUREAU OF FORESTRY.

Forester, GIFFORD PINCHOT,
Assistant Forester, OVERTON W. PRICE.
Assistant Forester, GEORGE B. SUDWORTH.
Chief Clerk, OTTO J. J. LUEBKERT.
Superintendent of Tree Planting, WILLIAM L. HALL.

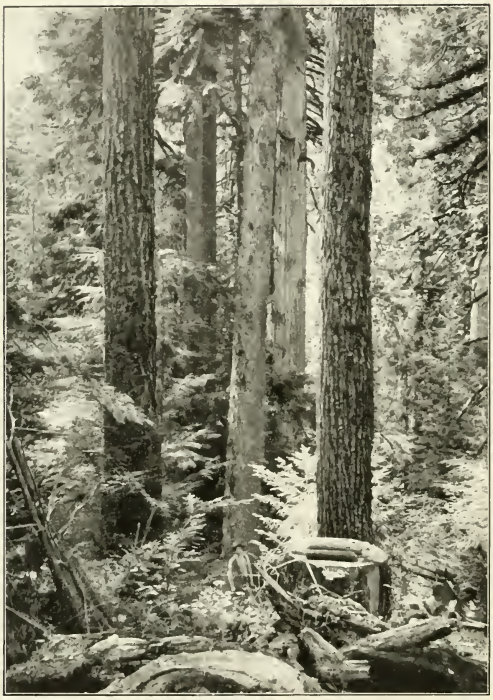
The D. H. Hill Library
North Carolina State University

NRRC
SD397
W45
A44
1902

THIS BOOK IS DUE ON THE DATE INDICATED BELOW AND IS SUBJECT TO AN OVERDUE FINE AS POSTED AT THE CIRCULATION DESK.

NATURAL RESOURCES
RESEARCH CENTER
N. C. STATE UNIVERSITY

100M/Z 85



TYPICAL FOREST MIXTURE IN WASHINGTON. SPECIES, FROM LEFT TO RIGHT: RED FIR, SPRUCE, HEMLOCK, CEDAR, RED FIR.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 33.

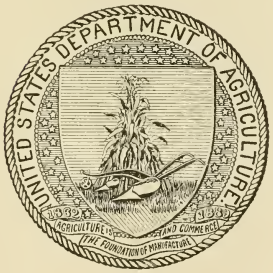
GIFFORD PINCHOT, Forester.

THE WESTERN HEMLOCK.

BY

EDWARD T. ALLEN,

FIELD ASSISTANT, BUREAU OF FORESTRY.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

LETTER OF TRANSMITTAL

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., March 8, 1902.

Sir: I have the honor to transmit herewith a report entitled "The Western Hemlock," prepared by Edward T. Allen, field assistant in the Bureau of Forestry, and to recommend its publication as Bulletin No. 33 of this Bureau.

Very respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

SUMMARY.

Western Hemlock has suffered so severely through the reputation of its Eastern relative among lumber manufacturers and consumers that it has at present scarcely any market standing. To remove this prejudice and to introduce the Western Hemlock to the market by pointing out its uses, its economic value, and the conditions under which it may profitably be grown, lumbered, and manufactured, was one of the purposes of a two seasons' study on the ground, the results of which are embodied in this report. The other purpose was to ascertain the qualities and possibilities for forestry of a tree that must inevitably take on great importance in conservative lumbering in the Northwest.

The conclusions to which this study has led may be briefly summarized as follows:

(1) The wood of the Western Hemlock is far superior to that of the Eastern tree. It is suitable for use in all ordinary building work; it furnishes good paper pulp; it is sufficiently light and strong to make excellent woodenware stock, and it is particularly valuable for indoor finishing. Its bark is half again as rich in tannin as that of the Eastern tree.

(2) Under favorable conditions the Western Hemlock reproduces abundantly and grows very rapidly. Since these conditions are usually disadvantageous to Red Fir, hemlock may often be counted upon to reforest cut-over lands when Red Fir would probably fail to establish itself.

(3) The Western Hemlock has now to contend mainly with a prejudice which is based upon a knowledge of the Eastern tree alone. The importance of bringing it into the market on a large scale as a substitute for Spruce and White Pine is growing rapidly. Its qualities entitle it to rank among the valuable timber trees of this continent.

CONTENTS.

	Page.
Introduction	9
Distribution	9
Associated species	10
Undergrowth	11
Habit	11
Tolerance	11
Growth under cover	12
Demands upon soil and moisture	14
Reproduction	14
Enemies	15
Fungi (conk and ground rot)	15
Insects	16
Boring beetles	18
Black check	19
Immunity from white ants (termites)	20
Parasites	20
The wood	21
Durability	22
Defects	22
Uses	23
Manufacturing problems	24
Present market standing	24
Accessibility	26
Lumbering	28
Volume and yield, first-growth Hemlock	30
Logged-off lands	36
Volume and yield, second-growth Hemlock	40
Utilization of second-growth stands	44
Hemlock left after lumbering	46
Bark	48
Volume and yield	50
Harvesting	52
Extract	53
A list of the trees of Oregon and Washington	54

ILLUSTRATIONS.

PLATES.

Page.

Typical forest mixture in Washington ..... Frontispiece.

PLATE I. Figs. 1 and 2.—Pure stand of Western Hemlock, Cascade foothills, Washington 10

II. Typical mixture of Red Fir and Hemlock, Black Hills, Washington. 10

III. Fig. 1.—Semi-Alpine forest of Noble Fir, Red Fir, and Western Hemlock, Mount Rainier Forest Reserve. Fig. 2.—Western White Pine, Cascade Mountains, Washington 10

IV. Fig. 1.—Young Hemlock growing on Red Fir stump. Fig. 2.—Hemlock, second growth, 12 to 14 years old, on logged-off land, near Hoquiam, Wash 14

V. Fig. 1.—Hemlock seedlings growing on rotten wood. Fig. 2.—Hemlock, second growth, 15 years old, on logged-off land, near Hoquiam, Wash 14

VI. Fig. 1.—"Conky" living Hemlock, showing fruiting organs. Fig. 2.—Distortion of trunk and branches of Hemlock caused by Arceuthobium occidentale 16

VII. Fig. 1.—"Black check" in Hemlock lumber, caused by insect injury when tree was small. Fig. 2.—Hemlock near Hoquiam, Wash., killed by Buprestid larvæ 16

VIII. Fig. 1.—Fasciation of Hemlock branch, caused by Arceuthobium occidentale. Fig. 2.—Hemlock stump cut high to avoid ground-rot 20

IX. Fig. 1.—Second-growth Red Fir, 70 years old; Dryad, Wash. Fig. 2.—Mature Red Fir, 380 years old; young Hemlock beneath; Black Hills, Washington 30

X. Fig. 1.—Logged-off land, Buckley, Wash.; Hemlock and diseased Fir left standing. Fig. 2.—Hemlock left after logging, Enumclaw, Wash., showing stumps of Red Fir 38

XI. Pure second-growth Hemlock, 55 years old, South Bend, Wash 40

XII. Figs. 1 and 2.—Western Hemlock, Cascade Mountains, Washington, showing thick, rough bark of mountain form 52

TEXT FIGURES.

Fig. 1.—Diagram showing height growth of mature Red Fir and of Hemlock growing beneath it, calculated on a basis of age 12

2.—Diagram showing diameter growth of mature Red Fir and of Hemlock, calculated on a basis of age 13

3.—Diagram showing growth in height of second-growth Hemlock and Fir, on a basis of diameter breasthigh 40

4.—Diagram showing growth in diameter of second-growth Red Fir and Hemlock in pure stands and of Hemlock in mixture with Red Fir.. 41

5.—Diagram showing yield per acre in board feet on a basis of age of pure even-aged Hemlock with and without deduction for cull 43

THE WESTERN HEMLOCK.

INTRODUCTION.

The stimulus apparent in the lumber industry of the Northwest within the last few years, with the recent immense investments in standing timber in that region and the realization that its supply is limited, has created an interest in the long-despised Western Hemlock. This species forms 13 per cent of the forests of Washington and is abundant in many parts of Oregon. Apparent inability to utilize it is one of the most serious factors in the local lumber problem. Were it practicable for the Hemlock to stand unharmed until it became established in the market there would be less cause for immediate concern. But, seldom growing in pure stands, the Hemlock in mixture with the Red Fir, Spruce, and Cedar now being logged is left standing by the lumberman to be destoyed by fire, wind, or insects, a complete loss to the owner and to the community.

This waste is in line with the history of lumbering in the Northeastern and Lake States, but with more serious result and with less justification. The Eastern Hemlock is an inferior wood, and therefore was left uncut until more valuable species became scarce. The disadvantage of the Western Hemlock has been not its quality, but its confusion with the Eastern species. It has been condemned without trial except by a few, who, realizing the difficulty of convincing the market, have manufactured under the names of Fir, Spruce, or Alaska Pine as much Hemlock as they dared without fear of detection.

The importance of bringing Hemlock into the market on a large scale is now being realized and its surreptitious use is somewhat greater than it was formerly. There is still, however, a total lack of organized effort, and practically nothing is done to acquaint the consumer with its merits.

DISTRIBUTION.

The Western Hemlock extends from Alaska southward to Marin County, Cal., to the coast region in California and southern Oregon in the southern, and east to Montana in the northern, portion of the belt. The first printed mention of the species occurs in an account of the voyage of Admiral Vancouver, a British navigator, who visited Puget Sound in May, 1792. In July of the following year Alexander Mac-

kenzie, the first white man to cross the North American continent, saw the Hemlock in latitude 52° on the coast of what is now British Columbia. The first description of the tree was published in 1814 in the journal of the Lewis and Clarke Expedition, which passed the winter of 1805 near the mouth of the Columbia River. These explorers spoke of it as a tree "four to six feet in diameter, straight, round, and regularly tapering."

The distribution of the species indicates clearly its chief requirements to be a cool and moist climate. Western Washington and Oregon, where it reaches its best development, are divided into three longitudinal belts, each with distinct characteristics of soil and climate. The western strip, between the Pacific Ocean and the Coast Range (which becomes the Olympic Mountains in the north), has a fertile, usually clayey soil and an annual rainfall of from 70 to 100 inches. This strip contains a large proportion of Hemlock, in mixture with Spruce, Cedar, and Red Fir. (See Frontispiece.) Between the Coast Range and the foot of the Cascades lies a belt which, protected from the moist sea winds, is comparatively dry. In Washington the soil is glacial drift, consisting chiefly of gravels; in Oregon it forms the rich agricultural lands along the Willamette and other rivers. In this belt there is little Hemlock, the growth being nearly pure Red Fir, with Cedar on the low ground, and some Pine. On ascending the west slopes of the Cascades the change is again distinctly marked. The soil is of either volcanic or sedimentary origin, and the increasing altitude causes condensation of the moisture which escapes the Coast Range and is carried eastward over the central valley. Here the Hemlock again appears and, at an altitude of from 1,500 to 3,500 feet, reaches its best development, and is most free from insect attacks and from disease.

ASSOCIATED SPECIES.

Hemlock rarely occurs in pure stands of great extent, although Clallam County, Wash., contains large forests of Hemlock, and there are tracts in Jefferson and King counties in which the percentage of other species is small. (Pl. I.) It commonly occurs in a mixture in which Red Fir is apt to be the prevailing species. (Pl. II.) Along the coast it is associated with Spruce and Cedar, and in northern California with Redwood. Occurring up to an altitude of nearly 5,000 feet, it is almost always one of the many species which form the widely varying mixture on the west slope of the Cascades. With Red Fir, Spruce, Cedar, and White Fir, it constitutes the forest now being lumbered in the foothills; higher, its associates are White Pine (Pl. III, fig. 2), Noble Fir, Amabilis Fir (Pl. III, fig. 1), and, near its upper limit, Alaska Cedar and the Alpine Hemlock. Toward the west slope of the Rockies, the eastern limit of its range, it becomes more distinctly a mountain tree and grows in what has been called the White Pine

FIG. 1.—PURE STAND OF WESTERN HEMLOCK, CASCADE FOOTHILLS, WASHINGTON. ALTITUDE, 1,300 FEET.

FIG 2.—PURE STAND OF WESTERN HEMLOCK, CASCADE FOOTHILLS, WASHINGTON. ALTITUDE, 1,300 FEET.

TYPICAL MIXTURE OF RED FIR AND HEMLOCK, BLACK HILLS, WASHINGTON.

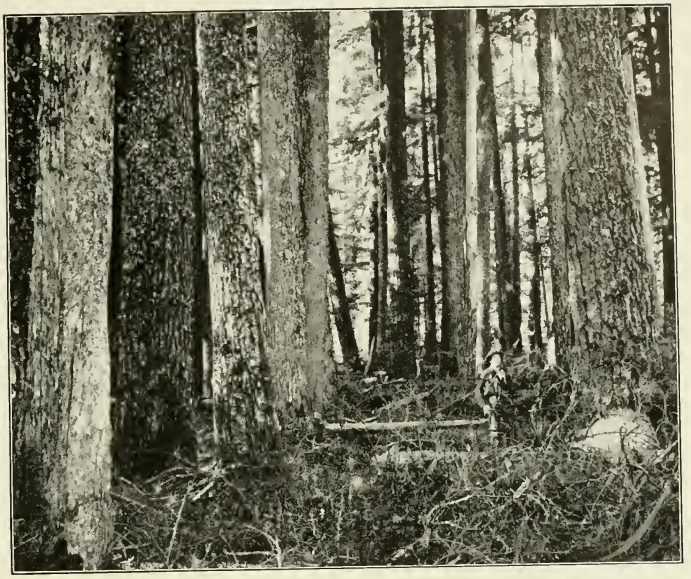


FIG. 1.—SEMI-ALPINE FOREST OF NOBLE FIR, RED FIR, AND WESTERN HEMLOCK, MOUNT RAINIER FOREST RESERVE. ALTITUDE, 2,400 FEET.

FIG. 2.—WESTERN WHITE PINE, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 2,500 FEET.

zone. Other trees in this zone are Tamarack, Engelmann Spruce, Lodgepole Pine, and Cedar. Throughout the range of the Western Hemlock broadleaf trees are so few that they are of no consequence as factors in the mixture. Where the climate is too dry to be generally favorable, Hemlock takes refuge on north slopes and in shaded valleys, where it can hold its own against Fir mainly because, since fire is infrequent, the latter finds an unsuitable seed bed and insufficient light in such localities.

A list of the trees of Oregon and Washington contains a few which seldom or never occur in mixture with Hemlock, but it is given for reference on page 54.

UNDERGROWTH.

Since Hemlock rarely forms a pure stand it has no characteristic undergrowth of its own. Vine Maple is common and Oregon Grape, ferns, and mosses constitute the smaller growth. In low, wet situations Devil's Club and Salmonberry are often abundant. No shrub is more characteristic of the pure fir forest than Salal, which prefers a dry soil and is therefore not much in evidence in the moist localities where Hemlock is at its best. Where it occurs forest reproduction is poor, for Salal covers the ground with a dense thicket 2 or 3 feet high. The leaves are thick and oily and encourage rather than prevent fire. A list of some of the more important shrubs which occur in the forests of Washington and Oregon, will be found on page 55.

HABIT.

The Western Hemlock has been found with a diameter of 8 and a height of 250 feet, and these dimensions may occasionally be surpassed. As a rule mature trees are from 3 to 5 feet in diameter at breastheight. The trunk is exceedingly cylindrical, although often with a sudden, irregular buttressing near the base, due to the germination of the seed on a log or stump. The branches are small and pendulous, forming a narrow spire-shaped crown which offers little resistance to the wind and serves somewhat to offset the insecurity of a shallow root system. Near the top of the tree and where exposed to the light the foliage is exceedingly dense and tufted, appearing almost fascicled, a provision which secures a very large leaf surface. Overtopped trees are able to form spreading crowns, and thus to accomplish the same result. The Hemlock clears itself of branches somewhat slowly.

TOLERANCE.

Western Hemlock will germinate and grow under dense shade. This characteristic, called tolerance, is one of the most important factors in determining the composition of the forest. Red Fir requires abundant light in youth, and hence seedlings of this species do not

come up beneath a heavy stand of mature timber. Hemlock and Cedar thrive under cover and, where climate and soil are favorable, occur in stands containing trees differing widely in age, since young trees are continually growing up to replace those which die and are blown down. In a forest of Red Fir, however, the trees are practically of the same age and no reproduction takes place until a large proportion of them are removed and light is freely admitted to the ground. This is usually accomplished by fire.

Where, as is frequent, the forest consists of an upper story of large Fir and a lower story of Hemlock of varying age, it often occurs that

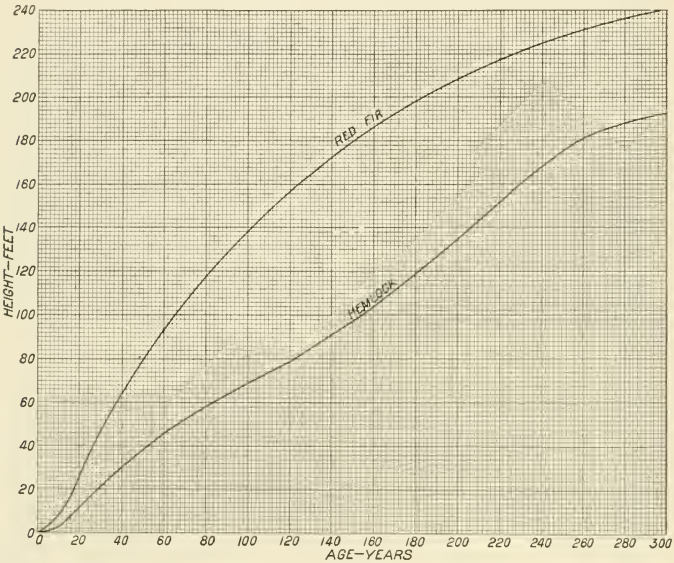


FIG. 1.—Diagram showing height growth of mature Red Fir and of Hemlock growing beneath it, calculated on a basis of age.

as the Fir dies the Hemlock gradually takes its place. Where Fir is killed out by conk or ground-rot, the process is often rapid; and examination shows that the small areas stocked with a pure growth of young Hemlock, so often seen in the midst of a Fir forest, were often caused by this means. It is probable that disease in the old Red Fir forests is largely responsible for the present distribution of Hemlock in Washington and Oregon.

GROWTH UNDER COVER.

No tree grows as rapidly in the shade as it does in the light, and Hemlock which has come in under Fir shows a close and often very

irregular grain. The rate of growth often quickens as the tree pushes up toward the light, and the grain becomes coarser and the wood lighter. Red Fir, on the other hand, or Hemlock which has enjoyed light in youth, shows a rapid growth near the heart and a slow growth near the bark, when age has diminished the rate.

A peculiar silvicultural problem is presented by the constantly diminishing density of the Red Fir overwood. Nearly all Red Fir forests start on burns or open land and are very dense for the first fifty or one hundred years. The young Hemlock which starts beneath the Fir during this period gets little light and grows slowly. Later, as

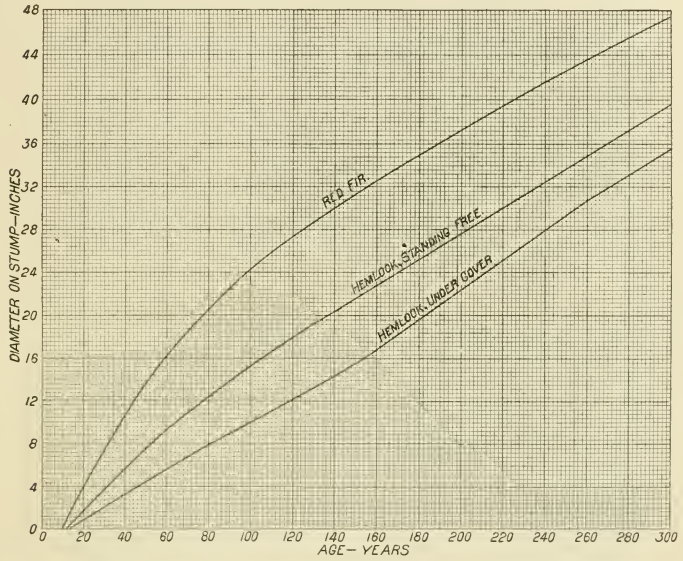


FIG. 2.—Diagram showing diameter growth of mature Red Fir and of Hemlock, calculated on a basis of age.

the Firs begin to crowd each other out, more light is admitted and the lower story of Hemlock grows more rapidly. Hence, the older the overwood the faster grow the Hemlock seedlings which come in beneath it. The culmination of height growth as the Hemlock approaches maturity therefore differs greatly from that under the usual forest conditions where the supply of light remains constant. Instead of falling off normally, as the trees approach maturity the growth of the Hemlock forming the lower story is constantly stimulated by the diminishing density of the upper story of Red Fir. (Figs. 1, 2.)

DEMANDS UPON SOIL AND MOISTURE.

The Hemlock ranges from mucky swamps to rocky hillsides. It requires, however, a heavy rainfall and is seldom found where the precipitation averages less than 40 inches annually, reaching best development where it is above 70 inches. The finest Hemlock in Washington grows at an altitude of 2,000 to 3,500 feet on the western foothills of Mount Rainier, where the annual precipitation is seldom less than 80 inches and snow lies half the year.

REPRODUCTION.

A prolific seeder and not fastidious as to seedbed, Hemlock reproduces freely under a wide range of conditions. In the drier inland regions, or where the soil has been severely burned, it does not rival Red Fir, but on the coast it far excels it. While Fir prefers a bare mineral soil, Hemlock reproduces better on a humus of leaves or rotten wood. (Pls. IV, V.) Stumps and fallen logs form a favorite seedbed, and large trees are often seen standing on leg-like roots, which, starting from the log or stump, have extended downward to the ground, finally to be left unsupported by the decay of their host. (Pl. IV, fig. 1.) Hemlock is thus enabled often to seed up ground where there is sufficient light for the germination of Fir. Insects, wind, or a ground fire may cause a tangle of fallen timber, later covering the ground with rotten wood. A few fires may start under such conditions, but Hemlock is likely to get the mastery. Near South Bend, Wash., is an illustration of this on a large scale. About sixty years ago the standing timber on a tract covering nearly a township was destroyed. No sign of fire is visible. Appearances indicate that this destruction was wrought by the measuring worm, which has since attacked large areas of Hemlock along the coast, notably near Grays Harbor and in Oregon. The original stand was chiefly Hemlock and Spruce; now, almost rotten, it covers the ground 1 to 2 feet deep. A few seed trees survive the catastrophe and record its date clearly by two or three very close rings, showing slow recovery from the injury, followed by greatly accelerated growth due to the increased light. Although there was an abundant supply of Red Fir seed, none germinated, and 90 per cent of the young growth now standing is Hemlock, with an occasional Spruce or Cedar. The Hemlock is of very rapid growth, averaging over 100 feet high and 13 inches in diameter at 55 years of age.

Hemlock bears seed almost every year. The age at which seed bearing begins varies with the amount of light in which the tree has grown. Trees coming up in burns may bear when 25 or 30 years old, but those which have grown in the woods do not bear until much later. The seeds, like those of most conifers, are winged and may be carried great distances by the wind.

FIG. 1.—YOUNG HEMLOCK GROWING ON RED FIR STUMP.

FIG. 2.—HEMLOCK, SECOND GROWTH, 12 TO 14 YEARS OLD, ON LOGGED-OFF LAND, NEAR HOQUIAM, WASH.

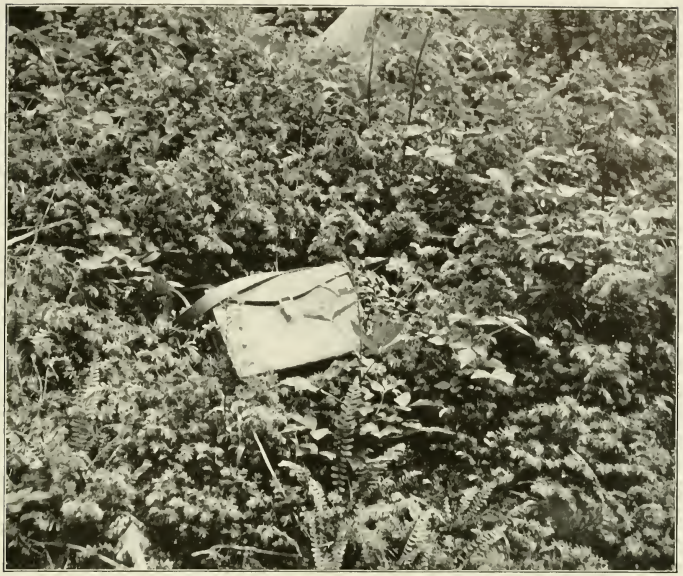


FIG. 1.—HEMLOCK SEEDLINGS GROWING ON ROTTEN WOOD.

FIG. 2.—HEMLOCK, SECOND GROWTH, 15 YEARS OLD, ON LOGGED-OFF LAND, NEAR HOQUIAM, WASH.

ENEMIES.

FUNGI (CONK AND GROUND-ROT).

Few Western trees maintain so continual a warfare to preserve existence as does the Hemlock. Its shallow root system is exposed to ground fires and also renders the tree unable to withstand heavy winds. The bark is thin, affording little protection against fire or other injury. The tree is liable in old age to attack by several fungi, notably conk (*Trametes pini* and *Echinodontium tinctorium*) and ground-rot (*Polyporus schweinitzii*). The latter is the more prevalent, and makes long-butting necessary in many localities. Little can be done as yet to prevent these timber diseases, but a better understanding of them may impress upon the lumberman the advisability of utilizing infected timber before it is ruined. Both conk and ground-rot are active, independent enemies of trees, and not, as is often believed, merely followers of disease due to unfavorable conditions.

The "conk" or bracket seen on affected trees is the fruiting organ. On its under side are innumerable minute spores or seeds. (Pl. VI, fig. 1.) These float through the air and lodge upon other trees. Conk spores never enter through the bark, but usually through the scars of broken branches. Once the spore is established, root-like fibers grow inward, destroying the structure of the wood. When sufficient nourishment has been extracted a small conk is produced, which grows by annual layers on its under side, and in turn liberates millions of spores.

Conk spreads rapidly, especially where the trees are badly scarred. Storms aid the disease by breaking many branches. Trees which have grown in an open stand in youth are apt to become conky because the branches are large, and, when they finally die off, they leave wounds which often do not heal over thoroughly. Damp climates and soils are favorable to the growth of conk.

In ground-rot the fruiting organs are on or near the roots. Hence the spread to other trees is usually brought about either by direct infection of interlacing roots or by the carrying of spores in the fur of burrowing animals. Hence ground-rot is apt to spread more slowly than conk and to be confined to spots in the forest. On the other hand, since the tender growing ends of roots may be infected without first being scarred, the existence of one diseased tree is almost certain to affect a group. Conk and ground-rot in Red Fir, Hemlock, and Spruce are caused by the same fungi and may be communicated from one species to another.

It is evident, therefore, that the immediate cutting of diseased trees is advisable, not only to save as much timber as possible, but in order to prevent the infection of others. The merchantable stand of many tracts of Red Fir in Washington has been reduced one-third by conk in ten years. It would often be better policy to incur considerable

expense in lumbering conky trees immediately than to cut only the sound timber near at hand.

The occurrence of fungous diseases is quite variable, but probably 20 or 25 per cent of all Hemlock under 3 feet in diameter is affected. Above that diameter the percentage is larger—possibly 50 per cent. Red Fir suffers much less, except in central and southern Oregon, where from 30 to 40 per cent is diseased. These estimates do not mean that so large a portion of the standing timber is actually lost, for often part of a diseased tree can be used, especially in the case of ground-rot, when long-butting constitutes the only loss. (Pl. VIII, fig. 2.)

INSECTS.

Dr. A. D. Hopkins, of the Division of Entomology, U. S. Department of Agriculture, who has charge of the investigation of forest insects, has kindly furnished the following information relating to the insects of the Western Hemlock, mainly quoted from data published by him:

Very little is known of the insect enemies of the Western Hemlock, or of methods of preventing losses from their ravages. During my investigation in the Northwest in the spring of 1899, under authorization from the honorable Secretary of Agriculture and instructions from Dr. L. O. Howard, some observations were made which convinced me that the Western Hemlock has some very destructive insect enemies.

In my preliminary report on the "Insect Enemies of Forests in the Northwest," Bulletin 21, N. S., U. S. Department of Agriculture, the following references are made to some of the insects observed:

On page 8, to an undescribed bark-beetle (*Hylesinus* sp.), which was found at Newport, Oreg., to be quite common in recently felled Hemlock.

On page 9, to a trouble which had caused the death of a large number of Noble Fir and Hemlock in the Cascade Forest Reserve near Berry, Oreg. While I was not able to secure specimens of the insects which doubtless caused the death of these trees owing to the fact that the trees had been dead too long, I concluded from the character of their work on the outer sapwood that it must be a Buprestid, possibly belonging to the genus Melanophila. Many of the wounds made by the insect had healed over before the trees died, thus presenting conclusive evidence that they were attacked while living and probably while in a healthy condition.

In the vicinity of St. Helen, Oreg., investigations were made of a serious trouble affecting the Hemlock and Red Fir, which proved to be similar to, if not identical with, that affecting the Hemlock and Noble Fir in the Cascade Reserve. The work of apparently the same Buprestid larvæ was found in healthy, dead, and dying trees, and I was fortunate in securing a few larvæ; also some nice specimens of healed-over galleries. The latter presented conclusive evidence that the attack had been made on healthy growing trees. It seems that the trees succumb only after several years of successive attack by this insect. The extensive cutting of timber for fuel carried on here does not seem to answer the usual purpose of attracting the insects away from the living trees; therefore this is a problem of considerable interest, and, under more favorable conditions for study, should receive attention in order to determine some methods of preventing the ravages, which may prove to be even more extensive than at present.

FIG. 1.—"CONKY" LIVING HEMLOCK, SHOWING FRUITING ORGANS.

FIG. 2.—DISTORTION OF TRUNK AND BRANCHES OF HEMLOCK, CAUSED BY ARCEUTHOBIUM OCCIDENTALE.

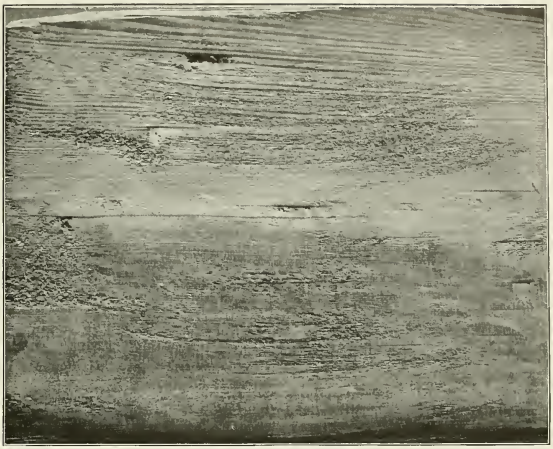


FIG. 1.—"BLACK CHECK" IN HEMLOCK LUMBER, CAUSED BY INSECT INJURY WHEN TREE WAS SMALL.

FIG. 2.—HEMLOCK, NEAR HOQUIAM, WASH., KILLED BY BUPRESTID LARVÆ.

In the vicinity of Ahlers (now Push), Oreg., I found a vast amount of dead Spruce and Hemlock. The trees had been dead eight or nine years, and hence it was not possible to personally investigate the cause of the trouble. I was particularly fortunate, however, in obtaining from the postmaster, Mr. Herman Ahlers, a most interesting account of the beginning and ending of the trouble as observed by him at the time. (Page 10.) The work of this insect has not, I believe, been previously recorded.

Mr. Ahlers says: "The worms commenced to attract a little attention here in 1889. A few moths were seen in the fall of the same year. In July, 1890, the worms appeared in great numbers, the first on the Hemlock, feeding on the base of the leaves and cutting them off. When standing beneath the trees the droppings from the insects and the falling leaves sounded like rain. When all of the leaves were eaten from the trees the worms would let themselves down by means of webs, and if they were not full grown would feed on the leaves of all kinds of shrubs and trees, except the Douglas Spruce and Cedar. The worms were observed during July and August and disappeared in the latter month, probably going into the ground to pupate. In October the moths began to come out. They were grayish white with dark markings on the wings. The wings spread about 1½ inches. The moths would appear on the wing about 3 o'clock in the afternoon in enormous swarms around the tops of the trees, resembling a white cloud. They continued to fly for about three weeks, at the end of which time the ground was covered with the dead insects, and the small streams were filled with them, in some places forming dams. The next year, 1891, they attacked the Sitka Spruce and defoliated the trees, which died the following fall or winter. * * * When the worms were coming down from the trees the webs made the trees look as if they were covered with a grayish veil. The worms were about 1½ inches long, the sides grayish green, with darker gray zigzag markings on the back. When traveling they measured their way. This trouble extended over parts of Clatsop and Tillamook counties, killing all the Hemlock and Sitka Spruce in a belt between elevations of about 450 and 1,200 feet above tide. The Douglas Spruce and Red Cedar were not injured." (Page 18.)

At the time of my visit much of the area covered by dead timber had been frequently burned over by forest fires, so that in some places nearly all of the dead timber had disappeared, but in other places, where the conditions had not been so favorable for the spread of the fire, the dead, barkless trunks of the trees were still standing, the tops broken and the branches fallen, the scene presenting at once a most impressive example of the destructive powers of an insect enemy of forests and of subsequent devastation by forest fires.

While the caterpillars, which were primarily to blame for this destruction, have not attracted attention in recent years, they will doubtless make their appearance again in destructive numbers and attack the remaining timber, which is becoming each year more accessible to lumbering operations, and hence rapidly increasing in value.

On page 17 further reference is made to the Buprestid enemy of the Hemlock, Red Fir, and Noble Fir:

"The evidence found in living, dying, and dead Noble Fir and Hemlock in the Cascade Forest Reserve at Berry, Oreg., and in Hemlock and Red Fir along the Columbia River in the vicinity of St. Helen, indicated that much loss of valuable timber had been due to the work of Buprestid larvæ in the living bark of these trees. The conditions at the time were not favorable for a study of this class of enemies or for a special investigation of the damage which seemed to be due to their attacks. It is, however, a subject of special importance, which will demand considerable attention in the future. Specimens of larvæ collected from the bark of living trees were provisionally identified by Mr. Schwarz as belonging to the genus

Melanophila, probably *M. drummondi*, which is closely allied to *M. fulvoguttata*, a destructive enemy of the Hemlock in West Virginia. An undetermined Cerambycid bark-borer was found associated with the Buprestid larvæ in Hemlock and Red Fir, but the evidence pointed to the Buprestid as having made the first attack."

These bark-infesting enemies are again referred to by me in the Forester, Volume VII, October, 1901, page 251, as follows:

"The Douglas Spruce bark-borer (*Asemum nitidum* Lec.), the Western Hemlock bark-beetle (*Hylesinus tsugæ* Hopk. MS.), and the Western Hemlock bark-borer (*Melanophila drummondi* Kirby), infest the living bark, and either kill the trees or cause gum-spots in the wood of the Douglas Spruce and Western Hemlock in Oregon and Washington."

They are again referred to in the Proceedings of the Society for the Promotion of Agricultural Science, 1891, pages 66, 67, under the head of "Some Insect Enemies of Living Trees," as follows:

"The Western Hemlock bark-beetle (*Hylesinus tsugæ* Hopk. MS.) attacks the living trees, and either kills them or causes defects known as gum spots in the wood of the Western Hemlock. It is found at Newport, Oreg., and Port Angeles, Wash.

"The Douglas Spruce bark-borer (*Asemum nitidum* Lec.) is a round-headed bark-boring grub, the larva of one of the long-horn beetles. It was found to be a very common enemy of the Douglas Spruce and Western Hemlock in western Oregon and Washington. The healed-over wounds in the living bark cause gum-spot defects in the wood, and the trees die from successive attacks.

"The Western Hemlock bark-borer (*Melanophila drummondi* Kirby) is a medium-sized flat-headed bark-boring larva of a Buprestid beetle. This insect excavates shallow winding burrows through the inner layers of bark of living Hemlock and Douglas Spruce. It was observed from California to northern and eastern Washington and western Idaho. This is a very common enemy, killing the largest and best trees or causing serious gum-spots in the wood of those which survive its attack."

BORING BEETLES.

Among the wood-boring beetles and flat and round headed wood-boring grubs, there are numerous species which cause more or less injury to the wood of living, dying, and felled trees. The wood-boring beetles cause pin-hole defects and bluing of the wood, which result in considerable loss to the manufacturer of lumber from this tree.

Much of this loss can be prevented by removing the bark from the logs of trees which are felled or remain in the woods for some time after the 1st of April, since, as a rule, most of these insects will attack only trees and logs which have the bark on.

It is the intention to make a special investigation during this summer to determine, if possible, the exact species to blame for the defoliation of the Hemlock and Douglas Spruce in western Oregon and Washington. Further investigation will also be made of the other insect enemies of the Hemlock and other forest trees of that region, the results of which will appear in a forthcoming bulletin of the Division of Entomology.

A tradition around Grays Harbor accounts for the disappearance of the insect that defoliates the Hemlock by affirming that the females are wingless, and, as the immense numbers rapidly destroyed the food supply, were unable to travel fast enough to reach fresh pastures before the males had eaten everything clean. This story is of some interest, inasmuch as there are species of Geomterid in which the

females have abortive wings, and a clue to the identity of the moth is suggested. It is also quite possible that it is founded only on ignorance of the history of insects and the supposition that the moth and caterpillar were of different sexes.

Were it possible to identify this insect, enough might be known of its habits to warrant predictions of its behavior in the future; under the circumstances it is possible only to say that another attack may occur at any time. Aside from the direct loss, the destruction of so large a body of standing timber creates, as suggested by Dr. Hopkins, a fire trap, which menaces the forests of the surrounding region, and it is quite possible that many of the former large fires of the coast region were due to this cause. With so great a rainfall and a dense green underbrush, the forest seldom, if ever, becomes dry enough to burn without some unusual aid, yet there is abundant evidence that the whole region has been swept clean by fire. It is difficult in any other way to account for the existing stand of old red fir, since it is a species which requires open ground for germination.

BLACK CHECK.

In 1900 the larvæ of an insect were discovered living in the bark and apparently causing a serious injury known as black check. Investigation showed this process in all its stages—the fresh wound, with the grub at work in it, partially covered scars of a year or two ago, and blackened spots buried several inches where they would be opened if the log came to the saw. The presence of larva is always betrayed by a flow of resin. Several specimens were collected and were identified by Messrs. Coquillot and Schwarz, of the Division of Entomology, as an unknown species of the family of Syrphidæ, genus Xylota. Since it is the habit of this genus to lay its eggs in the galleries of bark beetles, it seems probable that this species obtains entrance in the same way, although no evidence was found to show previous occupancy of the burrows. As such insects are often secondary and not originally responsible for the injury which is attributed to them, careful search was made for similar burrows not occupied by the Xylota larva, but none were found in an investigation carried on for several months. The most plausible explanation is that the female deposits the egg in the gallery of some Scolytid which does little or no damage to the tree, and that the attack on the wood is made by the Xylota larva upon emerging from the egg. In the fall the larva leaves the cavity and buries itself in the mass of pitch which has collected outside the bark, there assuming the pupal stage.

The only forest region found wholly free from this enemy was a belt along the west slope of the Cascades, above an elevation of 1,800 feet. If altitude proves responsible for this immunity, a similar region in the Olympics will probably also be found free from attack.

The danger is lessened by thick bark, which renders it difficult for the insects to enter. For the same reason large trees are safer than small ones. They are frequently streaked near the center, but not toward the outside, showing that when the tree reached a certain size its bark became thick enough to protect it. (Pl. VII, fig. 1.) As yet protective measures against this insect are unknown, but much disappointment might be prevented by an examination of standing timber for traces of the insects. It is useless for manufacturers of cooper stock or finishing lumber to buy infected logs. The presence of the larva in the standing tree is always apparent to a close observer.

IMMUNITY FROM WHITE ANTS (TERMITES).

Experiments made in Manila indicate that Hemlock may prove of special value in tropical countries where most woods are destroyed by ants. Capt. George P. Ahern, chief of the Philippine forestry bureau, states in a recent report that the master mechanic of the depot quartermaster's shops, Mr. D. N. McChesney, tested several American woods by thirty days' exposure to the attack of ants with the following results:

Oregon Pine (Red Fir)	Entered and eaten; a mere matter of time for complete destruction.
Bull Pine, Spruce	Eaten more readily than Oregon Pine.
California Redwood, California White Cedar	Ants tried, but discontinued after slight effort.
Hemlock	Not touched.

Further experiment is now being made. Since the depredations of ants are of great importance, not only in the Philippines but in other tropical countries, a wood which will withstand them is certain of a good market. Although Cedar and Redwood have the reputation of being ant proof, they are not adapted to many uses for which Hemlock is excellent.

For many years farmers have used Hemlock for the construction of oat bins and similar receptacles designed to be rat and mouse proof. It is said that the wood is distasteful to all rodents.

PARASITES.

A parasite (*Arceuthobium occidentale*) resembling mistletoe is widespread throughout the Hemlock region. It grows upon the branches and leading shoots, causing distortions and occasionally death. When the branches only are attacked, the result is a disturbance of their functions, and consequently a slow, sickly growth of the tree, which, however, does not affect the quality of the timber. If, however, the plant gets foothold on the leading shoot, a burl follows which persists

FIG. 1.—FASCIATION OF HEMLOCK BRANCH, CAUSED BY ARCEUTHOBIUM OCCIDENTALE.

FIG. 2.—HEMLOCK STUMP, CUT HIGH TO AVOID GROUND-ROT.

throughout the life of the tree and not only ruins a log, but renders the tree apt to be broken by the wind. (Pl. VI, fig. 2.)

The mode of propagation of Arceuthobium is curious. Male and female flowers are on separate plants, and the fruit, borne late in the fall, is a berry containing a sticky seed. When ripe, but only in dry weather, the berry explodes, throwing the seed several feet. If it happens to strike the branch of the same or another Hemlock, its glutinous covering enables it to adhere until it germinates and forces roots through the bark of its host. Since this is possible only on the thin, tender bark of young wood, the older portions of the tree are exempt. After a few years the parasite dies, but the distortion caused by it remains and the branch dies or remains permanently diseased. Its lateral growth usually stops and a fan-like mat of twigs radiates from the injured portion. (Pl. VIII, fig. 1.)

In a few coast districts and cool mountain valleys the Arceuthobium renders the Hemlock practically worthless, and by covering the ground with fallen trees and branches increases the danger from fire. The enfeeblement of the trees doubtless also facilitates the entrance of fungous diseases. Where the parasite is abundant, the trees die at the top and their crowns become tufted and narrow. It does not generally occur in sufficient quantity to be of economic importance and need not enter into a discussion of the use and future of Hemlock.

THE WOOD.

There is little similarity between the wood of the Eastern and Western Hemlock. That of the Western tree is light, rather hard, straight grained, tasteless, tough, and usually white, although often reddish-brown in the interior of the tree. This discoloration is not confined to the heartwood, but may extend into the sap, and is usually darkest where it does so. It is a serious defect in timber which is used for pulpwood, for finishing, or as a substitute for Spruce. Trees thus affected are commonly known by lumbermen as "Black Hemlock," and are frequently believed to be a different species. This does not refer to the true Black or Alpine Hemlock, which grows only at great altitudes and is not yet available for lumber.

In strength, ease of working, and freedom from warp and shake, Western Hemlock differs greatly from the Eastern species, whose deficiencies in these respects are its chief drawbacks. Western Hemlock can not be classed in strength with Oak, Red Fir, or Longleaf Pine, nor is it suitable for heavy construction, especially where exposed to the weather; but it possesses all the strength requisite for ordinary building material. It is largely used in Washington for mill frames.

When green, Hemlock contains much water and is very heavy; when dry it is but little heavier than Spruce, in some localities no heavier.

The following table gives the weights of thoroughly kiln-dried Hemlock and that of four well-known woods, per cubic foot:

TABLE 1.—*Weight per cubic foot of Hemlock and other well-known woods.*

	Pounds.
Western Hemlock	26.95
Eastern Hemlock	26.42
White Pine	24.02
Sitka Spruce	26.72
Red Fir	32.14

The weight given for Western Hemlock is the average of 1,500 feet B. M. taken from different Cascade camps at different times, and was obtained by a member of the Bureau of Forestry. The weights of the other species are quoted from the Tenth Census of the United States, Vol. IX. The weight of Hemlock varies greatly with locality and rate of growth, and in the tree itself.

DURABILITY.

The durability of this timber is still largely a matter of conjecture. There are no recorded experiments, and it has until recently been but little used. It is probable, however, that its durability has been greatly underrated. Although not a hardwood, it has given satisfactory service in floors for several years. It is the general experience that Hemlock skids, dams, and bridges in the woods are short lived, but this may be in part because the wood is used unbarked and never becomes dry. Green Hemlock is exceedingly sappy, heavy, and liable to attack by fungi and insects. It is not adapted for use partly in the ground. While the popular prejudice has prevented its extended use for piles, a few instances go to prove that Hemlock piles last almost if not quite as long as those of Fir. In salt water both stand until destroyed by teredoes or limnoria; in fresh water Hemlock lasts about ten years. Hemlock is, however, softer than Fir and more apt to be crushed in driving, and is less able to withstand a great strain successfully. In ease of working it is between Fir and Spruce, taking a smoother surface and cutting more easily than the former. It is readily turned, and the straight, even grain renders it free from brashiness or tendency to chip. There is very little contrast between the hard and the soft grain, and this feature, with the absence of pitch, makes it susceptible of a beautiful finish.

DEFECTS.

The chief of these are "black streaks" or checks, black knots, and the red heart already described. The latter is serious when the infected wood is used for pulp, on account of the color of the product; as lumber, it is undesirable for ornamental work and prevents substi-

tution for Spruce. It is, however, easily detected and the logs may be scaled down accordingly. The black knots, due to a fungous disease occurring where shade-killed branches have improperly healed, almost wholly ruin the lumber in which they occur. They are, however, confined mostly to trees near the coast. The black streaks, which have resulted in bewilderment and consternation on the part of those who have tried to manufacture finer articles of Hemlock, is a widespread and serious evil for which no remedy is as yet apparent. They are from three-quarters of an inch to 3 inches long, seldom over five-eighths wide, and very thin. (Pl. VII, fig. 1.) The streaks lie with the grain and become very conspicuous if the log is bastard sawn. In boards cut across the grain they are less conspicuous, but kiln drying is apt to open them clear through the board and to render the latter useless where tightness is required. This is one of the chief objections to the use of Hemlock for woodenware, for which it is otherwise excellent. This defect, varying greatly in degree, is widespread throughout Washington and Oregon and necessitates care in the selection of Hemlock from certain localities. It is less prevalent upon the higher slopes of the Cascades, while toward the upper limit of the tree the defect does not occur.

Besides the three defects mentioned above, Hemlock lumber frequently shows the perforations of boring beetles. This is, however, usually the result of careless handling of the logs and is too local in distribution to be quoted as an objection to Hemlock lumber generally.

USES.

Hemlock is best adapted for uses which require ease of working, a handsome finish, and lightness combined with considerable strength. It has been found suitable for flooring, joists and scantling, laths, siding, ceiling, box shooks, turned stock, newel and panel work, woodenware, and paper pulp. It is, however, for finishing and box manufacture that it is most certain of appreciation when it becomes better known. Taking a high polish, free from pitch, and, when properly sawed, showing a beautiful grain, it is an excellent wood for wainscot, panels, and newels. It is harder and less easily dented than Redwood or Cedar, and has a uniformly firm grain which on drying does not show the minute corrugations characteristic of Red Fir and other trees having a marked difference between summer and fall wood. The St. Paul and Tacoma Lumber Company, of Tacoma, has an office finished in Hemlock which attracts much admiration, and builders of many stores and residences on Grays Harbor have selected it as the most ornamental of Western woods for inside finishing.

Of greater economic importance, however, is the use of Hemlock as a substitute for Spruce and White Pine in the manufacture of boxes. The scarcity of timber suitable for this purpose is a cause of much

concern even in the West. The United States Geological Survey estimates the quantity of standing Spruce in Washington at less than 6½ billion feet. Oregon contains much less. Spruce is in demand for pulp as well as for box material and woodenware stock, and the available supply is going rapidly. Spruce logs are the dearest in the market, and Spruce is not easy to get at any price.

Hemlock is not used for pulp in Washington. Probably half the quantity now sawed in that State goes into "Spruce" boxes, for the manufacture of which it is admirably adapted in color, weight, and tastelessness. The objections are that very thin stock is more apt than Spruce to split and that on account of "black knots" only clear lumber can be used. The latter objection is confined mainly to timber from near the coast. With the failing supply of Spruce the necessity for the general use of Hemlock becomes urgent, but so far few manufacturers have had courage to use it under its own name, and its substitution for Spruce can be carried on only to a limited extent. Were it well understood that Hemlock boxes are practically as light and tasteless as those of Spruce, a market for Hemlock would be opened immediately. An evidence of the adaptation of Hemlock for food packages is the fact that early settlers in Washington invariably used it for hewn tubs in which to pack their winter butter.

After considerable experiment a large paper mill at Lowell, Wash., has decided unfavorably against Hemlock. On the other hand, it is largely used in Oregon, where it is pronounced better than the Eastern species. Since it is impossible altogether to avoid red-hearted or "black" logs, the color is the chief objection and makes the use of ground Hemlock pulp impracticable for the manufacture of better grades of paper, although soda and sulphite processes bleach the wood sufficiently unless it is unusually bad. The Oregon mills buy only upland logs. Those from the coast are apt to be faster grown, of coarser fiber, darker, and more frequently affected by black knots. Several camps in Oregon put in large quantities of Hemlock for pulp alone and receive on an average $4.50 per thousand. The bark is frequently given away on condition that it be removed from the log. It brings $10 to $12 a cord at the tannery.

MANUFACTURING PROBLEMS.

PRESENT MARKET STANDING.

Except to a limited extent for pulp, Western Hemlock is at present absolutely without standing in the market. A few million feet are cut annually, but are manufactured and sold under the name of Spruce or Fir. It is a breach of confidence for the logger to disclose the name of a customer to whom he sells Hemlock. It is never quoted in local trade journals. Notwithstanding these facts, mill men almost uni-

versally admit that they consider it an excellent timber and deplore the conditions which prohibit its use. There are three main reasons for this state of affairs:

(1) The prejudice of the consumer, who condemns Hemlock without trial because of its name.

(2) Hitherto Fir and Spruce have been so cheap that there has been no necessity for using Hemlock.

(3) Hemlock is heavy when green and apt to give trouble in driving and in ponds.

To overcome the prejudice against the name will be difficult, for to introduce an unknown timber to the market usually requires years. The practice of selling Hemlock as Fir when manufactured into flooring, siding, and dimension stuff, and as Spruce in the form of box-shooks and woodenware, has grave drawbacks. If detected, as he frequently must be, the mill man must either lose a customer or bring satisfactory proof of the excellence of the Hemlock. If he is able to accomplish the latter, he might as well have done so originally and the problem would thus have been solved. A mill which makes the substitution also furnishes a weapon of revenge to rivals and to employees with a grievance. It works a hardship to timber owners; for, with no recognized price for the timber, they are at the mercy of the mills. Some individuals have decided that, as the name is the drawback, it should be changed; and an attempt has been made to introduce Hemlock as Alaska Pine. This has been successful to some extent, and if it had been attempted earlier might have solved the problem.

The second reason no longer exists. The standing timber of the Northwest is going into the hands of large holders, either mill companies or speculative syndicates, and the day of the small logger, who moved from claim to claim, taking only the best timber, will soon be over. Under the old system, when the logger bought the stumpage, he found it most profitable to take only the best Fir and leave a fair merchantable grade uncut. An apparently unlimited supply enabled him to continue this wasteful system. Under such conditions it was not surprising that Hemlock was neglected. As a rule, it furnishes less clear lumber than Fir, and when only the best of the latter species was taken at a cost to the mill but little more than that of logging it, the utilization of Hemlock was out of the question. It was never cruised, and was left as entirely unconsidered in the buying and selling of timber land as though it did not exist. Now, however, it is becoming more and more the rule for timber to be cut by its owner, or, if not, to be sold by the acre, and it is to the interest of the logger to cut all he can from the land. In the case of Fir, lower stumps and shorter tops are put on the landing which would not have been looked at ten or even five years ago. The owner also realizes that a log of Hemlock used is a Fir log saved, and the only question is how to dispose of it.

The third objection will be discussed under the head of lumbering. There is little doubt that if Hemlock logs brought $5 a thousand, even the heavy butts would find their way to market.

ACCESSIBILITY.

A restricted home demand and remoteness from other markets are the chief difficulties before the lumber manufacturer in Oregon and Washington. Although timber is cheap, labor is high, and to sell his lumber he must place the price so little above the cost of logging and manufacture that the business is one of uncertainty and slender profit. The result is that although lumbering is carried on upon an immense scale, the State is being denuded of its timber with little profit beyond the employment of the men engaged in producing the lumber. The owner gets little for his timber, and the mill man receives an income trifling when compared with his investment and risk.

The reason for this is the cost of transportation. The manufacturer is obliged to depend upon the foreign cargo trade, the Eastern market accessible by rail, and locally upon Alaska and California. The latter is the dumping ground for side and common lumber which can not be profitably shipped a long distance. The cargo trade is peculiar in that the market is fairly steady and no great energy in pushing the product is required, but it is governed very largely by ocean freight rates. If grain be moving the lumber shipper will find it impossible to charter a vessel. Owners dislike to load lumber, both because it is supposed to be bad for the ship and because it often takes her to a port which furnishes no return cargo. If, on the other hand, the prospect for grain on the Pacific coast is bad, ships do not come there at all unless under charters which fully recompense them. The effect is that when rates are favorable the mills accept all the orders they can secure, make charters regardless of possible forfeit through delay, and run day and night, piling up immense amounts of nearly unsalable lumber. When matters turn the other way, the mills may run for months at a loss or with little profit so far as the cargo trade is concerned.

The following freight rates on lumber from the northern Pacific coast ports to foreign ports, for September, 1899, and September, 1900, are quoted from the San Francisco Commercial News:

TABLE 2.—*Freight rates on lumber from northern Pacific coast ports to foreign ports.*

	RATE PER 1,000 FEET, SEPTEMBER, 1899.
From Puget Sound to—	
Sydney, New South Wales	$11.25 to $11.75
Melbourne or Adelaide	13.12 to 13.43
Port Pirie, Australia	12.50 to 12.81
Freemantle, West Australia	15.93 to 16.25
Geraldton, West Australia	16.25 to 16.56

From Puget Sound to—	
West coast South America:	
Pisaqua range	$12.81 to $13.12
Callao range	13.12 to 13.43
Buenos Ayres	13.75 to 15.00
Shanghai	13.43 to 13.75
Kiaochow	13.75 to 14.06
Japan	12.50 to 12.81
South Africa	15.62 to 16.25
United Kingdom	17.50 to 18.12
Vladivostok	12.50 to 12.81

RATE PER 1,000 FEET, SEPTEMBER, 1900.

From northern Pacific coast ports to—	
Sydney, New South Wales	$13.12
Melbourne or Adelaide	15.00
Port Pirie, Australia	$14.37 to 15.00
Freemantle, West Australia	17.50
Geraldton, West Australia	17.81
West coast South America:	
Pisaqua range	15.62 to 15.93
Callao direct	15.31
Buenos Ayres	17.50 to 17.81
Shanghai	16.25
Kiaochow	17.50
Nagasaki, Japan	15.00
South Africa	18.12 to 18.75
United Kingdom	21.25
Vladivostok	16.25

Rail trade with the East is affected by a more fluctuating market and by vigorous competition, but is also regulated almost wholly by the cost of transportation. Except for the business in spars and heavy timbers, which are obtainable only on the Pacific coast, the eastern limit of trade is that point to which Oregon and Washington lumber can be delivered more cheaply than Southern or Northern Pine. The rate on Fir lumber from Puget Sound and Oregon at present is:

TABLE 3.—*Railroad rates on Fir lumber from Puget Sound and Oregon, per 100 pounds.*

Helena	$0.35	Pittsburg	$0.65
St. Paul	.40	New York	.73
Chicago	.50	Boston	.75
St. Louis	.52½		

Lumber other than Fir is, as a rule, 10 cents less per hundred pounds. This at present applies only to Spruce and Cedar, since these are the only other kinds which are shipped.

With the cost of logs at about $6 and of manufacturing at $3.50 per 1,000 feet B. M. these freight rates allow of little shipping of timber from west of the Rockies, although there is a prospect that satisfactory rates will soon be granted to Missouri River points. The bulk of the

lumber shipped to these points is for building purposes, for which Western Hemlock is thoroughly satisfactory. Since dry Hemlock (rough) weighs but 2,240 pounds per 1,000 feet B. M., and Fir weighs 3,000 pounds, the theoretical saving in freight on kiln-dried grades would be nearly one-fourth. The arbitrary weights accepted by the railway companies for the various grades of Fir might conflict somewhat with this comparison, but the advantage for long hauls in a decrease in weight of 20 per cent remains indisputable. The difference in the weight of air-dried stock of these two kinds may be less, since Hemlock is slow to dry and heavy when green, but with proper care it would still be considerable. Generally speaking, Hemlock lumber will probably be sold in the Missouri region from $2 to $3 cheaper per 1,000 feet B. M. than Fir on account of saving in freight alone.

LUMBERING.

With a few exceptions, it is only as skid timber that Hemlock enters the logger's calculations. These exceptions are where mills log their own lands, where small orders for box lumber or pulpwood are received, or where the Hemlock is unusually good. In all cases it is put in as a side product with a much larger quantity of Fir, for no logging is done in approximately pure Hemlock stands.

So far as Hemlock logs can be quoted at all, they bring about $4.50 per 1,000 feet B. M. for the largest and clearest, no others being handled. Fir of the same quality is worth $6 to $8. Most frequently the Hemlock logs are not classed as Hemlock, but are put in with the Fir and scaled at the option of the buyer as first or second grade Fir. A few camps put in from four to five logs a day, cutting only those they are sure will be accepted at the price of first-grade Fir. To sum up, the demand is so small and uncertain that the logger handles Hemlock only in a desultory and unsystematic way.

As a rule, there is little profit in logging on Puget Sound for less than $5 a thousand, and it actually costs many Red Fir camps $5.50 to deliver their logs at the mill. On Grays Harbor and the Columbia River the cost is a little lower. It is idle to attempt to state definitely the cost or profit of lumbering, since it varies from a net gain of $1 a thousand to losses resulting in bankruptcy; but the following table gives a rough average of the cost of lumbering 1,000 feet at Puget Sound camps:

TABLE 4.—*Average cost of lumbering per 1,000 feet at Puget Sound camps.*

Stumpage	$1.00	Average price of logs	$6.00
Labor	2.50	Cost	5.50
Engines, line, and road	1.00		
Haul to mill	1.00	Profit	.50
Total	5.50		

There is apt to be considerable variation in the items of expense. Timber lying on streams may bring $1.50 stumpage; that accessible only by rail is cheaper, but the cost of transportation often reaches $1.50. Estimates for the cost of engines, line, and road vary from 50 cents to $1 per 1,000 feet B. M., but probably the latter figure is more nearly correct. The scarcity of accessible timber makes private logging roads necessary in most instances, and these cost from $5,000 to $10,000 a mile. The expense for railroad per 1,000 feet B. M. depends upon the amount of timber rendered available and is exceedingly variable. The length of the haul and the character of the ground make a considerable variation in the outlay for wire rope. The following table, based upon an actual pay roll, shows the cost of operations in a camp which ships logs by rail and water to a distant mill:

TABLE 5.—*Cost per thousand feet.*

Labor getting logs to car	$2.50
Shipping to boom	1.30
Booming and rafting	.08
Scaling	.035
Returning boomsticks	.07
Mill discount	.11
Wear on outfit	.50
Total	4.595

This is exclusive of stumpage, which in this instance was 50 cents per 1,000 feet B. M., the timber having been purchased several years ago. The same timber is now worth about $1.

It would thus appear that with Hemlock logs at $4.50, or even $5, there is little profit in logging them. It is to be remembered, however, that a portion of the expense of lumbering, such as the cost of a railroad, is necessary in order to lumber the Fir, and thus can not be charged altogether against the Hemlock; and when, as is often the case, no account was taken of Hemlock when the timber was purchased, the cost of stumpage is also eliminated.

The difficulty of driving butt logs, because of their weight, deters many lumbermen from handling Hemlock. This difficulty varies greatly, and in many localities is of no importance. Hemlock near the coast is heavier when green than the Hemlock of the uplands, and, since river driving is also commoner there, gives the most trouble. Were the demand regular and extensive, however, means of avoiding this difficulty would doubtless be devised. A market for Hemlock bark would probably make it profitable to peel the logs in summer, and they would then dry out sufficiently to be driven successfully. There would then, however, be the danger from the boring-beetles, which have already been mentioned.

Hemlock, unless cut with the Fir, is usually lost. Fire is practically certain to run through the slashings. The thin bark of the Hemlock makes a severe fire fatal, and where a tree is only slightly scarred the boring-beetle is almost sure to attack it. With its shallow root system the Hemlock is also liable to be blown down when left unprotected, and even the drying of the soil, due to increased light, often proves fatal.

It is not uncommon for 5,000 to 25,000 feet of Hemlock per acre to be left standing on land from which the Fir has been removed. Allowing a stumpage value of only 25 cents per thousand feet, this represents a loss of $1.25 to $6.25 an acre. Or, putting it differently, if Hemlock gains a place in the market, it will raise the value of such timber from $1.25 to $6.25 an acre. In the case of pure, or nearly pure, Hemlock, a greater increase in value would be necessary to bring about the same result, for there would be no logging of Fir to lower the cost of logging the Hemlock. (Pl. IX.)

VOLUME AND YIELD, FIRST-GROWTH HEMLOCK.

Scribner's scale has been used in all volume and yield tables in this report. The universal custom of scaling at the small end of the log has been followed, although the scale was originally intended to be applied at the middle, where it is far more accurate. The prevailing practice undervalues large logs, and it is probably for this reason that the mills secured its adoption; but a return to the correct method here would result only in confusion.

The data for Table 6, which gives the contents of standing trees in board feet, were obtained by two methods, one based on the actual logging practice and one on the possible merchantable contents of the trees. The former included the scaling of several hundred trees as they lay in the slashings, cut into logs but not yarded out. The logs were scaled just as would be done by the camp or mill scaler, except that the total contents of each tree were kept separate. In this way the average contents of trees of different diameters and height were found. The average diameter limit in the tops to which the Hemlock was cut was 20.5 inches. In this way from 10 to 30 feet of merchantable, and sometimes clear, lumber is usually left, which will undoubtedly be used when Hemlock is better appreciated. The same trees were therefore also scaled to a point 16 inches in diameter inside the bark, unless the crown extended below this point, when the merchantable length was considered to end at the first large green branch. Table 6 gives the result of both methods.

FIG. 1.—SECOND-GROWTH RED FIR, 70 YEARS OLD, DRYAD, WASH.

FIG. 2.—MATURE RED FIR, 380 YEARS OLD; YOUNG HEMLOCK BENEATH, BLACK HILLS, WASHINGTON.

TABLE 6.—*Merchantable length and contents.*

Diameter breast-high.	Average total height.	Merchantable length.		Contents.	
		In practice.	Cutting to 16 inches.	In practice.	Cutting to 16 inches.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Board feet.*	*Board feet.*
20	135	.....	24	.....	240
21	140	.....	34	.....	350
22	144	.....	43	.....	465
23	148	37	52	550	580
24	152	44	60	680	700
25	156	51	68	800	825
26	159	58	74	920	955
27	162	63	80	1,040	1,090
28	166	68	84	1,150	1,230
29	168	71	87	1,260	1,365
30	171	73	89	1,360	1,490
31	174	74	91	1,450	1,605
32	176	74	92	1,540	1,715
33	178	75	93	1,630	1,820
34	181	75	93	1,710	1,925
35	183	75	94	1,780	2,030
36	185	76	95	1,850	2,135
37	187	77	96	1,920	2,245
38	189	79	97	2,000	2,360
39	191	81	98	2,080	2,480
40	193	83	101	2,175	2,605
41	194	86	103	2,280	2,735
42	196	89	106	2,400	2,870
43	198	90	109	2,550	3,010
44	199	91	112	2,730	3,160
45	200	92	115	2,940	3,320
46	202	93	119	3,175	3,490
47	203	94	123	3,430	3,670
48	205	95	126	3,680	3,870
49	206	96	131	3,920	4,090
50	208	97	135	4,155	4,310

In this table small trees appear to scale much too high in proportion to the larger ones. This is because only unusually tall and good trees of the smaller diameters are taken at all, and their average is relatively high, while above 30 inches practically all sound trees are cut.

To the logger who profits only on the number of feet he sells, Table 6 shows that his possible gain in feet, board measure, by cutting higher into the tops is small, even assuming he has a market for timber of the quality he would obtain thereby. A mill cutting its own timber would gain much more, for the inconsistency of the log scale is such that the table does not show the actual difference in the amount of wood saved by cutting to 16 inches. For example, a log 40 feet long and 16 inches in diameter at the small end, scaled by the Scribner Rule, contains 396 board feet. If 10 feet are cut off the small end of the log, allowing 2 inches taper for this distance, the log will be 30 feet by 18 inches, and will scale 400 board feet, an apparent gain of 4 feet by throwing away a log 10 feet by 16 inches. In sawing long

logs this discrepancy is in part justified by the loss in slabs, but there is no question but that on the whole a mill would gain more by cutting to a 16-inch limit than is shown by Table 6. The average difference in the merchantable length between cutting to 16 inches in the top and cutting as it is now done is shown to be from 15 to 20 feet.

The following table gives, on a basis of diameter breasthigh, the total height, length of crown, and merchantable length of Hemlock grown under cover and standing free:

TABLE 7.—*Total height, length of crown, and merchantable length.*

Diameter breast-high.	Under cover.			Standing free.		
	Total height.	Length of crown.	Merchantable length cut.	Total height.	Length of crown.	Merchantable length cut.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
8	.....	.....	.....	59.0	21.0	.....
9	.....	.....	.....	67.0	24.0	.....
10	.....	.....	.....	75.0	29.0	.....
11	.....	.....	.....	83.0	34.0	.....
12	.....	.....	.....	90.0	38.5	.....
13	.....	.....	.....	97.0	43.5	.....
14	.....	.....	.....	104.0	48.0	.....
15	.....	.....	.....	110.0	52.0	.....
16	.....	.....	.....	116.0	55.5	.....
17	.....	.....	.....	121.0	58.0	.....
18	.....	.....	.....	126.0	60.5	.....
19	.....	.....	.....	131.0	63.0	.....
20	135.0	77.5	37	135.0	64.5	.....
21	140.0	79.0	47	140.0	66.5	.....
22	144.0	80.0	51	144.0	68.0	.....
23	148.0	81.0	37	148.0	69.0	37
24	152.0	82.0	47	152.0	70.5	44
25	156.0	83.0	51	156.0	72.0	51
26	159.0	84.0	58	159.0	73.0	58
27	162.5	85.0	63	163.0	74.0	63
28	166.0	86.0	68	166.0	75.0	61
29	168.5	86.5	71	169.0	76.0	68
30	171.5	87.5	73	171.0	76.5	73
31	174.0	88.0	74	174.0	77.0	74
32	176.5	89.0	74	176.0	77.5	74
33	178.5	89.5	75	178.0	78.0	75
34	181.0	90.0	75	181.0	79.0	75
35	183.0	90.5	75	184.0	79.5	75
36	185.0	91.0	76	186.0	80.0	76
37	187.0	91.5	77	188.0	80.5	77
38	189.0	92.0	79	190.0	81.0	79
39	191.0	92.5	81	191.5	81.0	81
40	193.0	93.0	83	194.0	81.5	83
41	194.5	93.5	86	196.0	82.0	86
42	196.0	94.0	89	198.0	82.5	89
43	198.0	94.5	90	200.0	83.0	91
44	199.0	95.0	91	202.0	83.0	92

The following table gives, on a basis of diameter breasthigh, the percentage of the total volume of wood and bark of Hemlock, excluding branches, which is merchantable under present logging methods:

TABLE 8.—*Utilization under present logging methods.*

Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.
Inches.	*Per cent.*	*Inches.*	*Per cent.*	*Inches.*	*Per cent.*
20	45	31	65	42	73
21	49	32	65	43	74
22	53	33	65.5	44	75
23	55	34	66	45	76
24	58	35	66	46	77
25	60	36	67	47	77
26	61	37	68	48	77
27	62	38	69	49	78
28	63	39	70	50	78
29	64	40	71		
30	64.5	41	72		

The following table gives for Hemlock, on a basis of diameter breasthigh, the length of that part of the stem, including the stump, which will yield clear lumber, according to market specifications:

TABLE NO. 9—*Diameter and length of stem yielding clear lumber.*

Diameter breast-high.	Yielding clear lumber.	Diameter breast-high.	Yielding clear lumber.	Diameter breast-high.	Yielding clear lumber.
Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
20	27	27	46	34	56
21	31	28	48	35	56
22	34	29	50	36	57
23	37	30	51	37	58
24	40	31	52	38	59
25	42	32	53	39	60
26	44	33	54	40	61

Since the utilization of Hemlock where it occurs in mixture with Fir is of chief importance at present, no consideration is given here to the utilization of pure stands of mature Hemlock. The stand is given for localities where logging is most active and represents different types of the mixtures of Fir and Hemlock which form the larger part of the commercial forests of the Pacific Northwest. The percentage of Hemlock in the merchantable stand varies from 23 per cent at Orting to 59 per cent at Buckley. With Wilkeson these localities may be taken as a fair index to the stand of Hemlock on the western foothills of the Cascades, where the altitude is from 800 to 1,500 feet and the annual rainfall about 50 to 60 inches. The other places near which measurements of the stand were made were Hoquiam and Elma in Chehalis County, near the coast; Little Rock in Thurston County, and

Matlock in Mason County. It will be noticed that the percentage of Hemlock is highest on the coast and on the foothills, which is in proportion to the increase in rainfall.

The data for estimating the stand given in the following tables were obtained by the strip valuation survey method, which is in general use by the Bureau of Forestry. Strips 1 chain (66 feet) wide and 10 chains long to the acre were run in several directions through the forest to be estimated, and all trees on these strips were counted and measured at breastheight by calipers, or with a measuring tape, a separate tally being kept for each acre. At Orting, for example, the camps of the St. Paul and Tacoma Lumber Company were taken as headquarters, and the valuation survey parties followed compass courses radiating from the camps as a center, like spokes from the hub of a wheel. Since eight of these strips make a mile, the 325 acres measured at Orting aggregate a strip over 40 miles long and 66 feet wide. The contents of the trees in these strips were computed from the volume tables, constructed from the actual scale of felled trees. By this system the stand on large areas can be determined with great accuracy and at small expense.

All trees 20 inches and over in diameter breasthigh were scaled, which in most instances probably gives a trifle higher total stand than would actually be cut at present, since trees less than 2 feet are now seldom taken. No attempt was made to figure locally the cull due to unsoundness, for it is so variable that only confusion would result. All living trees 20 inches and over in diameter were scaled, whether defective or not, and a cull of 20 per cent was deducted for crooked, scrubby, or otherwise poor trees.

The number of acres actually measured in each locality is given at the head of each table. It should be borne in mind that these were carefully distributed over a large area and so far as the number and size of the trees are concerned represent the stand with very fair accuracy. The actual merchantable yield in board feet is necessarily dependent upon the standard in cutting. The yield of bark is computed for merchantable Hemlock only and assumes that the trees will be peeled to a point 17 inches in diameter in the tops.

TABLE 10.—*Stand and yield per acre in typical localities.*

WILKESON (400-YEAR-OLD STAND.)

[Average of 35 acres.]

Species.	Number of trees—		Average diameter breasthigh of trees—		Maximum diameter breasthigh.	Yield of trees 20 inches and over in diameter breasthigh.	
	6 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	6 to 19 inches in diameter breasthigh.		Lumber.	Bark.
			Inches.	*Inches.*	*Inches.*	*Bd. ft.*	*Cords.*
Hemlock	80.3	18.85	30.0	9.5	64	20,508	4.53
Red Fir	11.6	11.54	66.0	12.0	118	71,065	.....
Others	6.0	5.74	52.0	13.3	127	9,533	.....
Total	97.9	36.13	45.0	9.5	127	101,106	4.53

TABLE 10.—*Stand and yield per acre in typical localities*—Continued.

BUCKLEY (410-YEAR-OLD STAND).

[Average of 131 acres.]

Species.	Number of trees—		Average diameter breasthigh of trees—		Maximum diameter breasthigh.	Yield of trees 20 inches and over in diameter breasthigh.	
	6 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	6 to 19 inches in diameter breasthigh.		Lumber.	Bark.
			Inches.	*Inches.*	*Inches.*	*Bd. ft.*	*Cords.*
Hemlock	84.34	20.48	33.5	10.3	86	27,361	6.46
Red Fir	10.37	10.32	67.0	6.7	116	67,180	.....
Others	6.12	3.7	46.9	11.5	102	5,254	.....
Total	100.82	34.5	47.4	10.3	116	99,795	6.46

ORTING (250-YEAR-OLD STAND.)

[Average of 325 acres.]

Hemlock	43.78	10.86	27.8	10.1	92	9,800	2.06
Red Fir	29.35	24.08	40.0	14.4	116	48,080	.....
Others	19.89	11.48	37.0	11.8	228	9,809	.....
Total	93.0	46.4	37.0	10.9	228	67,689	2.06

ELMA (280-YEAR-OLD STAND.)

[Average of 87 acres.]

Hemlock	61.7	7.32	28.1	10.3	50	6,798	1.64
Red Fir	15.3	14.54	46.0	14.1	114	43,490	.....
Spruce	.8	.54	55.1	12.4	114	2,732	.....
Cedar	6.6	4.15	38.0	13.4	108	6,972	.....
Total	84.4	26.55	40.0	12.6	114	59,992	1.64

MATLOCK (260-YEAR-OLD STAND.)

[Average of 297 acres.]

Hemlock	47.73	10.09	30.7	11.1	56	11,485	2.53
Red Fir	37.75	29.31	40.0	16.2	.....	58,525	.....
Others	2.4	1.38	47.3	11.3	132	1,960	.....
Total	87.88	40.78	38.2	12.2	132	71,970	2.53

LITTLE ROCK (390-YEAR-OLD STAND.)

[Average of 61 acres.]

Hemlock	46.2	14.41	29.4	11.2	56	14,986	3.31
Red Fir	23.8	23.85	41.0	15.1	106	50,480	.....
Cedar	10.1	4.34	35.0	12.9	54	5,902	.....
Total	80.1	42.6	36.2	13.1	106	71,368	3.31

HOQUIAM (400-YEAR-OLD STAND.)

[Average of 89 acres.]

Hemlock	50.2	10.09	34.3	11.2	54	13,972	3.42
Red Fir	9.83	9.77	65.5	13.1	120	59,160	.....
Spruce	1.18	1.01	63.0	11.4	112	6,194	.....
Cedar	1.5	1.37	56.5	13.3	114	5,370	.....
Total	62.7	22.24	50.7	12.3	120	84,696	3.42

For fairer comparison the merchantable stand of Red Fir given in the tables was computed according to the average diameter limit to which the Red Fir is cut throughout the State, and not, unless through coincidence, according to local practice. Except in the case of pile or spar camps and of a few small concerns supplying tie mills, there is no great variation in the diameter limit to which Red Fir is cut on the stump. Usually a forest stand in which most of the trees are not over 3 feet in diameter is not considered merchantable at all. A common standard considers no tree merchantable which will not cut two 24-foot logs, each of which will square 16 inches. The distance into the top to which the tree is utilized varies greatly, however. Since the cost of logging, or of transportation, the quality of timber, or the demand for logs of certain lengths, may influence the amount taken out of a tree of a given diameter, it follows that each camp has its own standard, and this standard may fluctuate.

The following table shows the diameter inside the bark in the top to which Red Fir was being cut in several of the largest camps in Washington at the time they were visited by the agents of the Bureau of Forestry:

TABLE 11.—*Diameter limit in tops.*

Locality.	Diameter.
	Inches.
Buckley	31.8
Orting	17.5
Matlock	25.7
Elma	26.8
Little Rock	27.4
Hoquiam	33.3
Average	27.1

It is evident, from the above table, that volume tables made at Orting and Hoquiam would produce widely different results if applied to the same stand.

LOGGED-OFF LANDS.

Hitherto the problem of dealing with logged-off land has been given uniform treatment by Western lumbermen. It has been the custom to sell the land which had value for agriculture for what it would bring, especially for grazing, and to abandon the rest. Large tracts of logged-off land have been sold for 40 cents an acre. Occasionally an owner pays taxes on such property, but he is the exception, and often has some peculiar motive for doing so, such as a desire to show a large acreage. Very few expect to log a second time.

Excessive taxation in the United States is one of the greatest obstacles to conservative forest management by private owners. In western

Washington, cut-over lands, valuable for the production of timber alone, are assessed at a value of from $1 to $5 an acre, at a combined county and State rate of from 15 to 30 mills on the dollar. Assessors may attempt to make a more reasonable adjustment, but are often prevented from doing so by the demand of the State for a revenue from these lands far out of proportion to that required from other property. The State takes no account of the annual decrease of standing timber from cutting, and continues to levy the same tax, although it must be borne by less valuable land each year. In Chehalis County alone 10,000 acres are annually cut over, yet the tax rate is unchanged. An attempt was made to get logged-off lands placed in a separate lightly taxed class, and to have the burden divided among other classes of property, but it failed.

Calculating logged-off land as worth $1 an acre, with the assessment at $3 an acre, and the rate at 2 cents, the cost of holding a quarter section of such land for fifty years would be $1,742, or $10.90 an acre. It is thus evident that the community offers little encouragement to the timber grower. Under such conditions few men will hold logged-off land. The effect of the system is to defeat its own end. The property reverts to the State for delinquent taxes and, still considered worthless and wholly unprotected, it is burned and reburned until it becomes a desert. The gain to the community would be much greater were the land assessed at 50 cents an acre and the tax collected. Statements furnished by the assessors of several timbered counties in Washington show the amount of cut-over land which has been abandoned to be as follows:

TABLE 12.—*Amount of logged-off lands abandoned.*

County.	Assessed value of standing timber per acre.	Assessed value of logged-off land per acre.	Combined State, county, and special tax rate per acre.	Logged-off land abandoned.
	Dollars.	*Dollars.*	*Mills.*	*Per cent.*
Chehalis	8.00– 9.00	2.00	19	71
Clallam:				
Hemlock	2.00	1.00	29	[a]
Other species	8.00			
Clarke	5.00–10.00	2.50– 5.00	27	[b]
Jefferson	3.00–10.00	1.00	28	20
King	3.00–10.00	2.50	20	[b]
Pacific	2.50– 5.00	1.25	22–30	[c]
Pierce	4.00– 6.00	2.00– 2.25	20–30	[d]
Skagit	3.00–10.00	[d]	18	[e]
Whatcom	4.00–10.00	2.00–10.00	16	20

[a] None nominally abandoned. Much delinquent.
[b] None.
[c] None at present. Indications that large amount will be abandoned.
[d] Information wanting.
[e] Very little.

The laws of Washington prohibit the sale of any State lands for less than $10 an acre; therefore the large and increasing area of abandoned lands, except the small portion which may become valuable for farming, must continue to be State property until it can find a purchaser at $10 who is willing to take up the tax burden which could not be borne even when the land was offered for $1. This area must therefore remain absolutely unproductive, nontaxpaying, and, on account of fire, a menace to adjacent standing timber.

So deplorable a state of affairs entails far more than financial loss to the State and its inhabitants. It is generally admitted that the exhaustion of the mature timber of the United States is a matter of but one or two generations, and that thereafter second growth must be used to supply the natural needs. It is the Pacific coast region, with its warm climate and heavy rainfall, which promises the most certain and rapid return of logged-off land to forest, and to this region the country will naturally turn for much of its timber supply in the future. With the exception of the Government forest reserves, no provision is being made to meet this demand, and for this condition of affairs unwise taxation is largely responsible.

Over the larger part of western Oregon and Washington, Red Fir is the tree which takes possession of burned-over land, and, if undisturbed, it does so almost immediately. It is at present the most valuable timber tree of the region, and its readiness to reforest denuded land seems exceedingly fortunate. There are, however, certain regions in which there is practically no reproduction of Fir, and here the market future of Hemlock will fix the profit of growing a second crop. This is largely the case along the coast.

The present practice is to cut all good Fir and Spruce and to leave the Hemlock and only such Fir as is conky or otherwise unsound and hence unable to play an important part in reseeding the lumbered area. (Pl. X, fig. 1.) There is, of course, the adjacent untouched forest, which, under some conditions, would, by the aid of the wind, seed up openings as fast as they might be made by ordinary lumbering; but here the Fir bears irregularly and scantily, and little seed is produced. On the other hand, the Hemlock, which is left untouched in the slashings and forms a large part of the neighboring forest, bears abundantly every year. Furthermore, the slashing may escape fire, in which case Fir seed finds an unsuitable seed bed and is shaded too much by uncut Hemlock and underbrush. The final result under such conditions is a dense stand of Hemlock, often some Spruce, but only occasionally a Red Fir. (Pl. X, fig. 2.)

It is not impossible that this result might often be somewhat modified by judicious burning. While many loggers prefer, if possible, to avoid fire altogether, there are two arguments for a contrary course—safety in the future and a better chance for reproduction of Fir. There remains little doubt that fire after logging greatly assists this

FIG. 1.—LOGGED-OFF LAND, BUCKLEY, WASH. HEMLOCK AND DISEASED FIR LEFT STANDING.

FIG. 2.—HEMLOCK LEFT AFTER LOGGING, ENUMCLAW, WASH., SHOWING STUMPS OF RED FIR.

species to reproduce successfully. If fire is to run, it is usually safer to burn at that time in the spring when the slashing is inflammable but the surrounding woods are still too wet to be in danger than to allow a large area to remain unburned until the dry season, when fire is sure to be destructive.

In the coast region, owing to the frequent rains, the burning of the slashings as a precautionary measure is not so necessary as it is inland. Therefore, before adopting it in order to facilitate the reseeding of Fir, it should be ascertained whether it would not be more profitable to give up Fir altogether and make the most of the Hemlock. To decide this question a careful study of conditions on the ground is necessary. The amount and condition of young Hemlock must be excellent in order to make it worth preserving should there be a chance of obtaining Fir by its removal. (Pl. X, fig. 2.) A few half-grown trees are of little value, for without shade they will not clear themselves of branches. (Pl. X, fig. 1.) An undergrowth of suppressed, misshapen Hemlocks a few feet high, such as is often seen in dense timber, is not apt to make a healthy growth. In fact, the sudden advent of light often destroys Hemlock which has grown in the shade. Where such conditions prevail, and if the Fir in the vicinity can be counted on to reproduce itself upon the logged-off area, it is unprofitable to adopt a method favorable only to Hemlock.

It should be remembered, however, that, where the ground is covered by a foot or more of rotten wood and humus, fire may kill the young Hemlock and still not expose the soil sufficiently to encourage germination of Fir. Even slightly injured Hemlock is worthless, for it is almost certain to be attacked by borers. Blazes, fire scorch, and scars from rigging, in fact, anything which deadens a small portion of the bark, encourages their entrance. Other insects and parasites should also be remembered. In a region where such enemies of Hemlock as black streak, borers, and Arceuthobium are prevalent, it would be wise to destroy a fair growth of Hemlock for the sake of a much younger stand of the more hardy Fir.

To sum up, where Fir is a poor seeder and where it is desirable to prevent fire entirely from the first, there is little use in trying to get anything but Hemlock for a second crop, and in such a case there is nothing to do except to protect the slashing from fire. Where the Fir left standing is vigorous enough to seed freely and a fairly clean burn can be secured, it would often seem the best policy to fire the slashing in the spring. It is the purpose of this report, however, to deal not with Red Fir problems, but with those of regions in which reproduction of Red Fir is impracticable. Assuming, then, that from observation the owner of timber land is satisfied that the second growth will be chiefly of Hemlock, he will naturally wish to know how long it will be before it will produce merchantable timber, what its value will be, and how much it will have cost him. In order to answer these ques-

tions as authoritatively as possible, a study of second-growth Hemlock was made, the results of which are given in the following chapter.

VOLUME AND YIELD, SECOND-GROWTH HEMLOCK.

The study of second-growth Hemlock has so far been confined to the coast region. The results obtained can also be applied with fair accuracy to second growth upon the western slope of the Cascades, where the rainfall is nearly as heavy as it is near the Pacific. The most important localities selected as representative of coast conditions were near South Bend and Willapa, in Pacific County, Wash. The former

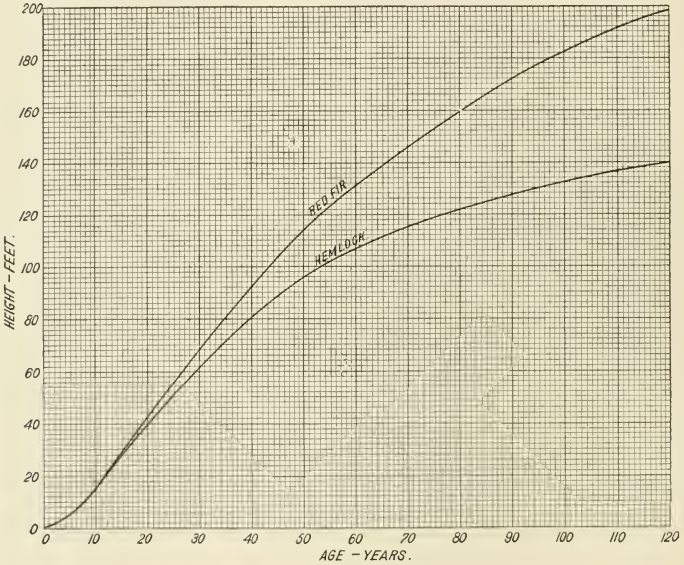
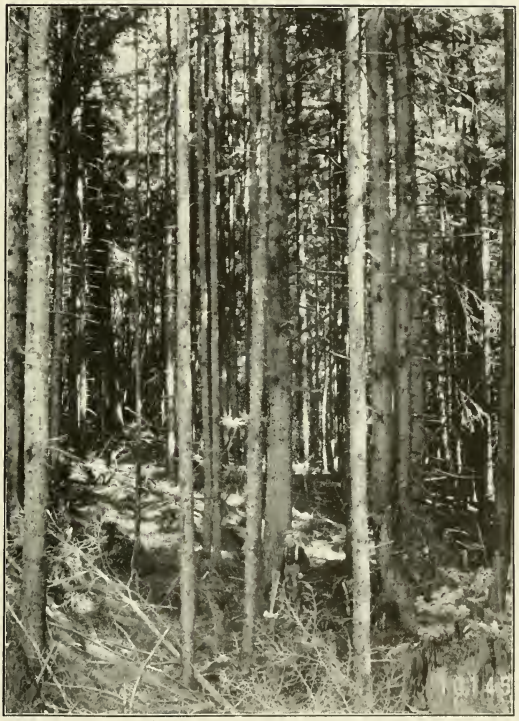


FIG. 3.—Diagram showing growth in height of second-growth Hemlock and Fir, on a basis of diameter breasthigh.

contains a large tract of pure Hemlock, almost uniformly 55 years old (Pl. XI), which formed the basis for the study of pure stands. Near Willapa were found, in addition to a pure stand of Hemlock, a typical mixture of Fir and Hemlock about 75 years old, which illustrated the behavior of the species when growing in mixture. A mixed stand 120 years old was found at Stella, Cowlitz County, on the Columbia, and studies of similar stands were made elsewhere throughout the State.

Although it is not difficult to find sufficient stands of second growth to show what may be expected upon logged-off lands, there is no logging in these stands. In order, therefore, to compute yield tables, it



PURE SECOND-GROWTH HEMLOCK, 55 YEARS OLD, SOUTH BEND, WASH.

was necessary to create an arbitrary standard of merchantable size. It was assumed that in fifty years, the probable shortest time in which land now bare can be logged again with profit, timber will have gained in value sufficiently to warrant the cutting of any tree which will yield a log 20 feet long and 12 inches at the small end. A few of the trees 13 inches in diameter breasthigh will contain such a log, but it was thought safer to take 14 inches as the limit. In the subsequent discussion of second growth, therefore, all trees 14 inches and over are considered merchantable, and it is assumed that all timber between the stump and a point 12 inches in diameter inside the bark will be utilized.

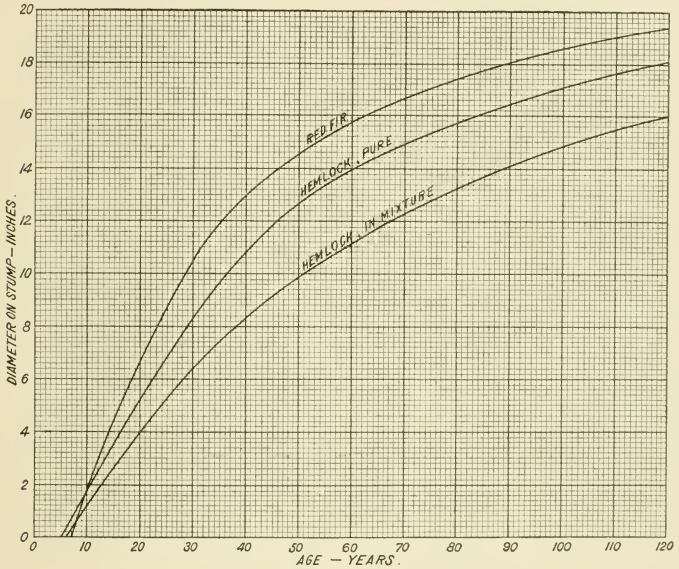


FIG. 4.—Diagram showing growth in diameter of second-growth Red Fir and Hemlock in pure stands and of Hemlock in mixture with Red Fir.

Such material as piling or trap poles will be produced in less than fifty years, but earlier than this the trees will not clear themselves sufficiently to make merchantable sawlogs, even if a few reach the requisite size.

The growth of pure and mixed even-aged forests is very different. In the former, Hemlock grows rapidly, with a normal relation between diameter and height growth. The stand is exceedingly dense at first, and remains so longer than does a Red Fir forest on account of the greater tolerance of the Hemlock. The growth in height and diameter is also slower than that of Red Fir. Where, however,

Hemlock comes in with Fir on denuded land, it is after the first few years influenced by its more rapidly growing rival. The Fir soon overtops it by a few feet, but the ability of Hemlock to live under such conditions prevents it from being shaded out. The result is that the height growth of Hemlock in mixture with Fir is as rapid as that of a pure stand, and that the suppression is shown by a falling off in its diameter growth. Figs. 3 and 4 show graphically the growth of Hemlock and Fir and the growth of the same species, both when in mixture and when in pure stands. These curves represent conditions near the coast, and are somewhat higher than would be an average for the State.

The following two tables give, on a basis of diameter breasthigh, the total height, length of crown, and merchantable length of second-growth Hemlock in mixture with Fir and in a pure stand:

TABLE 13.—*Mixed stands, Hemlock and Red Fir, 75 years old, Willapa.*

Diameter breasthigh.	Total height.	Length of crown.	Merchantable length.
Inches.	*Feet.*	*Feet.*	*Feet.*
14	121	53.0	21
15	127	57.0	27
16	132	60.0	34
17	136	62.0	42
18	139	63.0	51
19	142	64.0	58
20	144	65.0	64
21	145	65.5	69
22	145	66.0	73
23	145	66.0	77
24	145	66.0	80
25	145	66.0	83

TABLE 14.—*Pure stand of Hemlock, 55 years old, South Bend.*

Diameter breasthigh.	Total height.	Length of crown.	Merchantable length.
Inches.	*Feet.*	*Feet.*	*Feet.*
14	107	50	24
15	109	52	29
16	111	53	35
17	113	54	42
18	115	55	48
19	116	56	53
20	117	56	56
21	118	57	59
22	119	57	62
23	120	58	64
24	120	58	66
25	120	58	66

The character of three typical second-growth stands in Washington is shown in Table 15, which is the result of surveys and measurements similar to those made in mature timber and previously described. It will be noted that in Willapa, where the mixture of Hemlock is most uniform, the stand is unusually heavy for its age. This is in part due to the fertility of the soil and a very heavy annual rainfall, but probably also to the composition of the mixture, for a tract of given size can support a heavier forest of mixed Fir and Hemlock than of either species alone. It is evident that, since the future yield of a second crop is influenced by the mixture of species, knowledge of the rate of growth

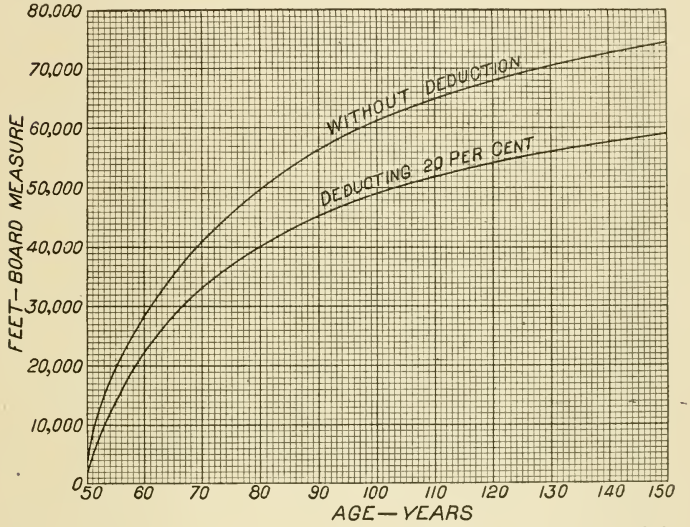


FIG. 5.—Diagram showing yield per acre in board feet on a basis of age of pure even-aged Hemlock, with and without deduction for cull.

will not suffice to foretell it unless the composition of the mixture is known. It is useless, therefore, to make hard and fast tables of future yield for indiscriminate application to the varying growths which may occur after logging. For a pure stand the problem is much simpler. Fig. 5 represents graphically the stand which may be expected from pure even-aged Hemlock near the coast of Washington. It includes second growth only and not those trees which may escape the first cutting. The upper curve shows the yield without allowance for cull; the lower curve, the yield after 20 per cent for dead, diseased, scrubby, or otherwise unmerchantable trees has been deducted.

TABLE 15.—*Stand and yield per acre in typical localities.*

STELLA (120-YEAR OLD STAND).

[Average of 155 acres.]

Species.	Number of trees—		Average diameter of trees—		Yield of trees 14 inches and over in diameter breasthigh.	
	6 inches and over in diameter breast-high.	14 inches and over in diameter breast-high.	14 inches and over in diameter breast-high.	6 to 13 inches in diameter breast-high.	Lumber.	Bark.
			Inches.	*Inches.*	*Board feet.*	*Cords.*
Hemlock	10.8	3.28	20.9	8.0	1,592	0.29
Red Fir	47.1	44.36	28.6	10.9	57,312	.....
Cedar	.7	.28	21.1	9.0	146	.....
Total	58.6	47.92	28.3	8.9	59,050	.25

WILLAPA (90-YEAR OLD STAND).

[Average of 65 acres.]

Hemlock	42.4	13.9	22.1	7.7	8,146	1.64
Red Fir	54.6	45.1	25.5	10.6	39,344	.....
Spruce	13.5	6.7	26.5	8.2	6,430	.....
Cedar	.5	.2	25.3	8.8	140	.....
Total	111.0	65.9	23.9	8.4	54,060	1.46

SOUTH BEND (55-YEAR OLD STAND).

[Average of 131 acres.]

Hemlock	126.3	55.2	19.5	8.4	16,190	4.2
Spruce and Cedar	14.2	7.2	21.7	8.8	2,075	.....
Total	140.5	62.4	20.6	8.6	18,265	3.6

UTILIZATION OF SECOND-GROWTH STANDS.

Assuming that in the future there will be a considerable area of second-growth Hemlock, the question arises, at what age can it be most profitably logged and how shall the forest be perpetuated? This can be discussed only in a general way, for it depends greatly upon the development of Hemlock as a commercial timber and upon the uses to which it is put. The tables in this report show that small sticks, such as are suitable for trap poles, may be cut in forty years, and that in fifty years logs will be produced which would be considered of fair size in the East to-day. In this time, however, according to fig. 5, there will be only a little over 2,000 feet to the acre, which even, allowing a stumpage of $1 per 1,000 feet, is an insignificant amount. Considering it as a fifty-year investment, there will have been a mean annual production of about 40 board feet an acre. At the end of sixty years the stand will be 22,000 feet, or a mean yield of 366 feet. The annual increment increases to 471 feet for a seventy-year period and reaches 500 feet at eighty years. At eighty-five it is but a few feet

more, and from then on it decreases steadily in rate of production. It appears, therefore, that the greatest production of wood can be secured by cutting second-growth Hemlock when it is about 80 years old.

However, there are other points which weigh in the consideration of the cutting age. If it is intended to keep the land perpetually in forest, provision must be made for a third crop, and it will not do to cut at a time when natural reproduction is doubtful. Early in the life of an average second-growth Hemlock stand there are many small trees which gradually become shaded out and killed by their more vigorous neighbors. If no cutting is done before the end of eighty years, most of these will have died and rotted, and if everything down to 14 inches is cut there will be few trees left to form part of a third crop. If the cut is made at sixty years, there will be a good nucleus left for a third crop, but the cut will be small and the timber inferior. The most profitable plan seems to be to wait a few years longer and to trust to natural seeding if a third crop is desired. At first, because of the dense shade, there is little or no reproduction beneath second-growth Hemlock. However, after about sixty years or more, according to the density, the Hemlock bears seed and the gradual thinning out of the stand admits sufficient light for the germination and growth of seedlings. If the forest is cut when 80 years old, many of the seedlings will live, and with those which spring up in the slashing will form sufficient basis for another stand. There will also be many fair-sized trees left standing, some of which, at least, will not be thrown by wind. So far as can be judged at present, the cutting age or rotation of largest yield need not be abandoned in order to insure reproduction.

The rotation of greatest financial profit still remains to be reckoned, for this is not necessarily identical with that of the greatest wood production. It is determined by the period at which the value of the crop represents the highest interest on the capital invested. Owing to the uncertainty of taxation and of the future value of Hemlock stumpage the calculation can only be tentative.

The actual sale value of denuded land in the coast counties of Washington can safely be placed at not over $1 an acre, or $160 for a quarter section. The land will probably be assessed at about $3 an acre and taxed at 2 cents on the dollar, which is 6 cents an acre, or $9.60 for the quarter section.

Were an owner to sell his land for $160 as soon as it was logged, and deposit the money in a savings bank at 3 per cent compound interest, adding annually the sum which he would pay for taxes had he held the land, the total amount to his credit at any given period would represent the cost of holding the land for a second crop during the same time. The calculation of this amount and its comparison with the value of the land and crop is found in Table 16. It illustrates

strikingly the possible loss or profit in holding logged-off land, assuming, of course, that the premises of taxation and stumpage are correct. The table shows that 70 years is the most profitable age at which to cut if stumpage is figured at either 75 cents or $1. At 50 cents the whole transaction is a losing one, and the longer the rotation the greater the loss.

TABLE 16.—*Financial result of cutting one quarter section of Hemlock after 60, 70, and 80 years.*

Time between cuts, or rotation, years.	Value of land and crop at end of rotation.			Proceeds of $9.60 deposited annually, at 3 per cent compound interest.	Gain by holding land.		Loss by holding land, stumpage $0.50.
	Stumpage.				Stumpage.		
	$1.00.	$0.75.	$0.50.		$1.00.	$0.75.	
60	$3,792	$2,884	$1,976	$2,451.40	$1,340.60	$432.60	$475.40
70	5,440	4,120	2,800	3,304.53	2,135.47	815.47	504.53
80	6,560	4,960	3,360	4,681.80	1,878.20	278.20	1,321.80

The largest profit shown above, that of a seventy-year rotation with a selling price of $1 stumpage, represents about 4.5 per cent compound interest upon the investment.

It should be clearly understood that these statements of profit are purely tentative, based upon tax rates and stumpage values which can not be foretold at present. They are believed to be conservative. The individual can, if he desires, make similar calculations upon such premises as seem in his judgment more probably correct.

From the foregoing pages it may be seen that the largest sustained yield is secured by cutting every eighty years, but that the interest on the invested capital which the crop represents is apparently highest at the end of seventy years. There still remains to be reckoned the bearing of age on the quality of the timber. This and many other questions concerning the future of second growth depend much upon circumstances impossible to foresee. It appears now that it will be about seventy-five years before the second crop can be logged to the best advantage. This does not mean that a considerable amount may not be cut earlier. And even if a long rotation is decided upon, earlier thinning would be beneficial if it could be made profitable. The difficulty lies in cutting small quantities and in disposing of small material which, at present at least, has no place in the market except possibly as trap poles.

HEMLOCK LEFT AFTER LUMBERING.

In the calculation of returns from second-growth Hemlock no account has been taken of small trees left standing after the logging of the old stand. If the slashing is burned these will be destroyed; if not, there will be left for a future crop a number which depends upon the character of the virgin forest and upon the intensity and

destructiveness of the lumbering. This number varies so greatly that it is futile to attempt a general estimate of it. It may, however, readily be ascertained on the ground, and the forester, by finding the rate of growth of the trees under the new conditions, can predict either how long it will be before a given amount can again be logged or how much can be cut after a given time.

Large tracts now being logged near Buckley, Elma, and Hoquiam were selected as examples. It was assumed that all trees above 20 inches were cut for logs and everything between 16 and 20 inches went into skids. The number of trees between 4 and 16 inches which would be left on an acre, if care was taken to destroy as few as possible, was estimated, and these were allowed a conservative diameter growth of an inch in five years for the next fifty years. Their contents in board measure (cutting to 14 inches) at the end of twenty-five and fifty years were then computed, and 25 per cent was deducted for trees which might die, blow down, or prove worthless for lumber. The results are here shown:

TABLE 17.—*Yield per acre from Hemlock left in lumbering.*

Locality.	Number of trees between 4 and 16 inches left on acre.	Yield per acre at the end of—	
		Twenty-five years.	Fifty years.
		Board feet.	*Board feet.*
Buckley	80	3,285	14,190
Elma	52	1,640	8,320
Hoquiam	36	1,745	6,875
Average	56	2,223	9,762

Hoquiam shows less than the normal number of trees for that part of the State, because of an insect attack several years ago, which destroyed many young trees. The figures for Buckley are included to produce a fairer average, although, as a matter of fact, this is a region in which Fir reproduction is feasible, and the burning of slashings is probably better policy than the protection of small Hemlock.

Since a few seedlings and a few vigorous trees which were less than 4 inches in diameter at the time of logging will become merchantable in fifty years, the yield will be somewhat more than the 9,762 feet indicated above. The addition on this account will probably bring the total to about 11,000 feet an acre, or 1,760,000 to the quarter section. At $1 a thousand this will be equivalent to a simple interest of 8.9 per cent on an investment of $1 an acre for the land and 6 cents an acre annual tax for fifty years.

The above calculations indicate a larger yield after fifty years than does fig. 5 for seedling second growth alone. Furthermore, the existence

of a few small trees does not preclude the development of a seedling stand also; therefore, the true second crop will consist of both and be greater than either alone. It will not be equivalent to a combination of both, for the ground and light demanded by the trees which are left standing will be denied to the seedlings. The exact manner in which this rivalry will be adjusted depends upon the number of trees left standing, the condition of the ground for germination of seeds, and numerous other factors which require a study of each case before even an approximate estimate is possible. On the other hand, there is no doubt that if a fair stand of Hemlock remains on cut-over land the yield given by fig. 5 will be increased by from 8,000 to 12,000 feet at the end of fifty years and by an indefinite amount after that time. This is assuming a nearly pure Hemlock reproduction. No attempt will be made to discuss Red Fir seedling growth under such conditions, for it is not apt to appear to any important degree unless there has been fire enough to destroy any small Hemlock which survives logging.

If it is desired to utilize small Hemlock in a future cutting, care should be taken not to injure it unnecessarily during logging. Promising trees need not be cut for skids where poor ones will suffice, and it should be borne in mind that scars caused by rigging, especially in setting strap leads, are almost certain to ruin young trees. Many trees ordinarily destroyed might be preserved at no additional expense by careful swamping, yarding, and falling.

BARK.

Although thinner than that of the Eastern species, the bark of the Western Hemlock is exceedingly rich in tannic acid. This has long been known to the trade, and several experiments have been made with a view to the establishment of extract works in the Northwest. A plant was actually started near South Bend, Wash., in 1893, but, owing to insufficient capital, to the general financial depression of the period, and, it is said, to the opposition of Eastern bark interests, it was soon shut down. The promoters claim, however, to have demonstrated the feasibility of a similar enterprise under more favorable conditions. In Oregon, where Hemlock is logged for paper pulp, the bark is utilized by local tanneries and brings from $8 to $12 a cord. The claim is made that it produces a lighter leather than Eastern bark.

So little use is made of the bark that it is difficult, in comparing it with that of the Eastern Hemlock, to determine to what degree its thinness is compensated for by its superior quality. The bark of the Eastern tree averages about 10 per cent tannin. The few available analyses of Washington Hemlock bark vary with locality and through absence of system in selecting samples, but unite in allowing about 16 per cent. Samples collected in Washington by the Division of Forestry

were submitted to the Division of Chemistry of the Department of Agriculture and the following results were obtained:

TABLE 18.—*Analyses of bark of Western Hemlock from Washington.*

	No. 21272. Little Rock, Thurston County.	No. 21273. Ashford, Pierce County.	No. 21274. Enumclaw, King County.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	9.87	10.55	10.01
Total solids	14.32	24.03	22.16
Soluble solids	13.78	22.59	20.58
Reds	.54	1.44	1.58
Nontannins	4.01	6.59	5.72
Available tannins	9.77	16.00	14.86
Woody fiber by difference	75.79	65.42	67.83

In his report upon these analyses Dr. Wiley, Chemist of the Department of Agriculture, says:

Nos. 21273 and 21274 are especially remarkable on account of being so rich in tannin. These barks are all of superior quality, especially the two just mentioned.

These two samples probably represent fairly the bark of the western slope of the Cascades, Enumclaw being about 1,000 feet and Ashford 2,000 feet above sea level. The Little Rock sample is apparently inferior, but can scarcely be regarded as representative, since it was taken from a fallen tree which had been exposed to heavy rains for several weeks. It is not improbable that a fresh sample would have compared favorably with the other two specimens.

In Hide and Leather, of June 24, 1893, appear the results of tests made by H. G. Tabor, manager of the American Extract Works, of Port Allegheny, Pa., which are as follows:

TABLE 19.—*Comparative analyses of Hemlock bark from Washington, Pennsylvania, and Quebec.*

	Washington.	Pennsylvania.	Quebec.
	Per cent.	*Per cent.*	*Per cent.*
Tannic acid	17.04	13.28	10.16
Nontannin	6.40	7.52	4.56
Reds	1.56	3.48	1.92
Wood fibers	75.00	75.72	83.36

Another analysis richer in tannin than either of the preceding was furnished by Professor Fiebing, of Milwaukee, to persons who contemplated starting an extract factory near the coast in southwestern Washington. He found the percentage of tannin in the two samples sent him to be 17.8 and 20.1, respectively. Allowing 2,240 pounds to

the cord, and assuming an average percentage of 10 for Eastern and 16 for Western bark, the quantity of tannin in each would be as follows:

TABLE 20.—*Yield of tannin per cord of Western and Eastern bark.*

	Pounds.
Washington bark	358.4
Eastern bark	224.0
Difference	134.4

VOLUME AND YIELD.

Although the cord is used as a standard of measure for bark, it is usually sold by weight, in order to avoid variation due to loose piling. Throughout the East 2,240 pounds are usually called a cord, although in some places 2,000 pounds are accepted. It was impossible to secure any yield tables based on actual practice in the regions covered by this report; therefore the thickness of bark at various heights was measured on all trees scaled, and the amount in cubic feet produced by the average tree of given diameter, and also by the acre, was computed. These figures were then converted into long and short cords on a basis of 66.6 cubic feet to 2,000 pounds and 77 cubic feet to 2,240 pounds. This was done separately for mature and second-growth timber, assuming that in the latter only the merchantable log length would be peeled, and that in the former all bark would be taken from the stump to a point where the tree is 12 inches in diameter. The following table gives, on a basis of diameter breasthigh, the volume of bark and the number of trees required to make a cord of 2,000 pounds and of 2,240 pounds.

TABLE 21.—*Volume of bark per tree and trees per cord.*

Diameter breast-high.	Cord of 2,000 pounds.		Cord of 2,240 pounds.	
	Bark per tree.	Number of trees per cord.	Bark per tree.	Number of trees per cord.
Inches.	*Cords.*		*Cords.*	
13	0.03	38.5	0.02	45.4
14	.03	33.3	.03	40.0
15	.04	26.4	.03	31.2
16	.05	21.8	.04	25.0
17	.06	17.0	.05	20.0
18	.07	14.1	.06	16.3
19	.09	11.8	.07	13.5
20	.10	9.8	.09	11.3
21	.12	8.3	.10	9.7
22	.14	7.1	.12	8.3
23	.16	6.2	.14	7.2
24	.18	5.5	.16	6.3
25	.21	4.8	.18	5.6
26	.23	4.3	.20	5.0
27	.26	3.9	.22	4.5
28	.29	3.5	.25	4.0
29	.32	3.2	.27	3.6

TABLE 21.—*Volume of bark per tree and trees per cord*—Continued.

Diameter breast-high.	Cord of 2,000 pounds.		Cord of 2,240 pounds.	
	Bark per tree.	Number of trees per cord.	Bark per tree.	Number of trees per cord.
Inches.	*Cords.*		*Cords.*	
30	0.25	2.9	0.30	3.3
31	.38	2.7	.33	3.1
32	.41	2.5	.35	2.8
33	.44	2.3	.38	2.6
34	.47	2.1	.41	2.4
35	.51	2.0	.44	2.3
36	.54	1.9	.47	2.1
37	.58	1.7	.50	2.0
38	.61	1.6	.53	1.9
39	.65	1.6	.56	1.8
40	.68	1.5	.59	1.7
41	.72	1.4	.62	1.6
42	.76	1.3	.66	1.5
43	.80	1.3	.69	1.4
44	.84	1.2	.73	1.4
45	.88	1.1	.76	1.3
46	.92	1.1	.80	1.3
47	.97	1.0	.84	1.2
48	1.01	1.0	.87	1.1
49	1.05	1.0	.91	1.1
50	1.10	.9	.95	1.1

Where bark is peeled from trees cut for lumber it is frequently the custom to reckon the yield by the amount produced to the thousand feet of logs, board measure. In the East half a cord to the thousand is considered a fair average, and is equivalent to about 112 pounds of tannic acid. On the Pacific coast the thinness of the bark and less economical logging practices unite to reduce this proportion, and a quarter of a cord to the thousand is all that can be relied on, but this will average 90 pounds of tannin. The yield per acre is necessarily exceedingly variable. For example, Table 11 represents regions where Hemlock forms a given per cent of the total stand of mature timber. Table 16 is for second growth. No figures were obtained for pure, mature Hemlock. The examples given compare favorably with the yield of pure Hemlock land in the East, where the best seldom exceeds 20 cords an acre and the average is about 5. Good authorities place the average crop for Pennsylvania at 7½ cords, for New York 4, and for Maine only 3 cords per acre. Taking a pure 55-year-old stand at South Bend, Wash., as a basis, together with cruisings and measurements in other young timber, it has been possible to figure with approximate accuracy the yield which may be expected from an average well-stocked acre of pure young Hemlock at a given age. The results are shown in Table 22. Only trees 14 inches and over in diameter breasthigh have been considered, and these peeled to a point 12 inches in diameter in the tops.

TABLE 22.—*Yield of bark per acre from pure second-growth Hemlock.*

	Age of stand.							
	50 years.	60 years.	70 years.	80 years.	90 years.	100 years.	110 years.	120 years.
	Cords.	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*
Allowing 2,000 pounds to 1 cord....	2.5	6.8	9.2	10.1	11.5	12.1	12.3	12.9
Allowing 2,240 pounds to 1 cord....	2.2	5.9	7.9	9.1	9.9	10.4	10.8	11.1

Toward the upper limit of the Hemlock, seldom below 2,400 feet above sea level, its bark often strikingly differs from that of the tree at lower elevations. It is exceedingly thick, often 2 inches, and is deeply furrowed. (See Pl. XII.) No volume or yield tables were made for this upland form, but it is probable that trees would contain twice as much bark as those of corresponding size at lower elevations.

HARVESTING.

In the East, where the methods of harvesting bark have developed into an established process, the usual peeling season extends from May to August, although the bark peels easiest from the first of June to the middle of July. Where bark alone is the object, a peeling crew consists of three men—faller, fitter, and spudder; but where the cutting is primarily for lumber, the first might be considered one of the logging crew. The fitter trims off branches, rings the bark at intervals of 4 feet, and slits each section lengthwise. The spudder peels the bark with a flattened bar and spreads it on the ground with the flesh, or inner side, up. After it has cured in the sun for five to ten days it is carefully piled, exterior side uppermost, to complete the seasoning process, which, unless the season is wet or the bark is piled in a shady place, requires but two or three months. It is highly desirable to remove the bark from the woods as soon as it is seasoned, for if left until winter it becomes covered with snow and ice, loses a considerable part of its tanning property, and curls badly; but in regions where roads are bad in summer it is often left to be taken out on sleds after snowfall.

It is evident that the wet climate of Oregon and Washington will prove somewhat detrimental to the economic handling of bark. Unfortunately, the heaviest rain occurs in the Hemlock regions. The thinness of the bark, the greater care required to cure properly, and the higher price of labor will tend to make the cost of production per cord greater than it is in the East. On the other hand, Hemlock stumpage is low, the bark is richer, and, since the roads are best in the fall, there need be no difficulty in getting it out when it is in the best condition.

FIG. 1.—WESTERN HEMLOCK, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 2,500 FEET, SHOWING THICK, ROUGH BARK OF MOUNTAIN FORM.

FIG. 2.—WESTERN HEMLOCK, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 3,000 FEET, SHOWING THICK, ROUGH BARK OF MOUNTAIN FORM.

On its arrival at the works the bark usually contains from 8 to 12 per cent of water. Fresh bark does not yield the acid readily. Hence when possible it is stored until fully cured, usually between one and two years. It is highly important to keep it well protected from rain, for it leaches easily and is soon ruined. For the same reason, bark from logs which have been towed or driven is of little value. Salt water ruins it entirely. If well cared for, nearly all the tannin in the bark is available. A cord of Eastern bark yields from 400 to 430 pounds of extract, which is sufficient to tan from 200 to 225 pounds of sole leather, or a trifle more of upper leather.

At present the available supply of hides in the Pacific Northwest is insufficient to support a tanning industry of any great proportions. It is probable that before there is a home market for any considerable quantity of bark it will be required to supply tanneries in the East, where complaint is already made of an inadequate supply. If this proves true, the product must be shipped in a condensed form and considerable capital will be required to develop the industry.

EXTRACT.

The process of making the extract is as follows: The bark is ground and placed in wooden vats, where it is steeped until the acids are removed. The resulting liquor is then evaporated in a vacuum at a temperature of about 180° F. until it is reduced to a heavy, dark colored fluid weighing about 10 pounds to the gallon and containing nearly all the tanning properties of the bark. Assuming the unsteeped bark to have 10 per cent of tannic acid, 100 pounds of it would produce about 40 gallons of 20° liquor, which, upon analysis, would show about 2½ per cent of tannin. The extract is usually shipped in 500-pound barrels and brings about 2½ cents a pound.

While the production of ground tan bark for local use is a simple process, the successful manufacture of extract requires even more expensive machinery than the manufacture of lumber. In the East, where machinery is cheaper than on the Pacific coast, a 10-barrel plant costs from $15,000 to $20,000. The leach house is much like that of a tannery, but an evaporating plant is also required in which all vats and pipes must be copper or brass lined, and this part of the establishment represents a large proportion of the entire expense. It is also customary to conduct a barrel factory in connection with the plant. From these considerations, it is apparent that extract works will be built only where there is certainty of a sustained bark supply and that, owing to the cost of transportation, Hemlock will probably be more valuable where it occurs in sufficient quantity to support a factory than in regions where the bark must be sent a distance to market.

A LIST OF THE TREES OF OREGON AND WASHINGTON, WITH SOME IMPORTANT SHRUBS.

Common name.	Scientific name.	Where found.
Sugar Pine	*Pinus lambertiana* Dougl	Oregon only.
Western White Pine	*Pinus monticola* Dougl	Semi-Alpine.
White-bark Pine	*Pinus albicaulis* Engelm	Alpine.
Bull or Yellow Pine	*Pinus ponderosa* Laws	
Jeffrey Pine	*Pinus jeffreyi* "Oreg. Com."	Oregon only.
Scrub Pine	*Pinus contorta* Loud	
Lodgepole Pine	*Pinus murrayana* "Oreg. Com."	
Knobcone Pine	*Pinus attenuata* Lemmon	Do.
Tamarack or Larch	*Larix occidentalis* Nutt	
Sitka or Tideland Spruce	*Picea sitchensis* (Bong.) Trautv. & Mayer.	
Engelmann Spruce	*Picea engelmanni* Engelm	Do.
Brewer Spruce	*Picea breweriana* Wats	Do.
Western Hemlock	*Tsuga heterophylla* (Raf.) Sargent	
Black or Alpine Hemlock	*Tsuga mertensiana* (Bong.) Carr	Alpine.
Red or Douglas Fir	*Pseudotsuga taxifolia* (Lam.) Britton	
White or Balsam Fir	*Abies grandis* Lindl	
White Fir	*Abies concolor* (Gord.) Parry	Oregon only.
Shasta Fir	*Abies shastensis* Lemmon	Do.
Alpine Fir	*Abies lasiocarpa* (Hook.) Nutt	Alpine.
Amabilis Fir or, erroneously, "Larch"	*Abies amabilis* (Loud.) Forb	Semi-Alpine.
Noble Fir or, erroneously, "Larch,"	*Abies nobilis* Lindl	Do.
Red Cedar or Giant Arborvitæ	*Thuja plicata* Don	
Alaska Cedar	*Chamæcyparis nootkatensis* (Lamb.)Spach.	Do.
Port Orford Cedar	*Chamæcyparis lawsoniana* (Murr.) Parl	Oregon only.
Incense Cedar	*Libocedrus decurrens* Torr	Do.
Redwood	*Sequoia sempervirens* (Lamb.) Endl	Do.
Juniper	*Juniperus scopulorum* Sargent and *J. occidentalis* Hook.	
Yew	*Taxus brevifolia* Nutt	
Willow	*Salix* (several species)	
Aspen	*Populus tremuloides* Michx	
Cottonwood	*Populus trichocarpa* Torr. & Gr	
Balm of Gilead	*Populus balsamifera* Linn	Do.
Paper Birch	*Betula papyrifera* Marsh	Washington only; very rare.
Western Birch	*Betula occidentalis* Hook	Rare.
Red Alder	*Alnus oregona* Nutt	
Mountain Alder	*Alnus viridis* De C	
White Alder	*Alnus rhombifolia* Nutt	
Western White or Prairie Oak	*Quercus garryana* Dougl	
Canyon Live Oak	*Quercus chrysolepis* Liebm	Oregon only.
California Black Oak	*Quercus californica* (Torr.) Coop	Do.
Tanbark Oak	*Quercus densiflora* Hook. & Arn	Do.
Wild Crabapple	*Pyrus rivularis* Dougl	
Black Haw	*Crataegus douglassii* Lindl	
Wild Cherry	*Prunus emarginata* (Dougl.) Walp	
Wild Plum	*Prunus subcordata* Benth	Do.
Bigleaved Maple	*Acer macrophyllum* Pursh	
Vine Maple	*Acer circinatum* Pursh	
Dwarf or Mountain Maple	*Acer glabrum* Torr	
Dogwood	*Cornus nuttallii* Aud	
Madrone	*Arbutus menziesii* Pursh	
Oregon Ash	*Fraxinus oregona* Nutt	
California Laurel	*Umbellularia californica* (Hook. & Arn.) Nutt.	Do.
Elderberry	*Sambucus glauca* Nutt	Chiefly in burns.

A list of the trees of Oregon and Washington, with some important shrubs—Continued.

SHRUBS.

Common name.	Scientific name.	Where found.
Salal	*Gaultheria shallon* Pursch	
Oregon Grape	*Berberis nervosa* and *B. aquifolium* Pursch.	
Salmonberry	*Rubus spectabilis* Pursch	
Devil Club	*Fatsia horrida* Benth. & Hook	
Red Huckleberry	*Vaccinium parvifolium* Smith	
Blue Huckleberry	*Vaccinium ovalifolium* Smith	
Wild Spiræa or Arrow-wood	*Spiræa discolor* Pursch	
Goat Brush, Buck Brush, or Wild Box	*Pachystima myrsinites* Raf	Semi-Alpine.
Manzanita	*Arctostaphylos tomentosa* Dougl	
Serviceberry	*Amelanchier alnifolia* Nutt	In burns.

In burns and open ground the plants of most importance are the common Fern or Brake (*Pteris aquilina* Linn), Blackberry (*Rubus ursinus* Cham. & Schlecht), Thimbleberry (*Rubus nutkanus* Mocino), and Fireweed (*Epilobium spicatum* Lam.).

○

HECKMAN
BINDERY INC.
JUNE 87
N. MANCHESTER,
INDIANA 46962